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Project Avenger Training Effectiveness Evaluation

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14. ABSTRACT

The DoD services are exploring methods to address growing pilot shortages by re-imagining training methodologies and integrating emerging technologies to create more effective and efficient training. Falling under the umbrella term "Training Next," these efforts were started by the Air Force with its experimental Pilot Training Next (PTN) program and are continuing with the Army and Navy as Aviator Training Next (ATN) and Naval Aviation Training Next (NATN), respectively. NATN implemented its first major syllabus revision in 2020 with Project Avenger, a Fixed Wing Primary syllabus update employing the following novel principles: competency-based, individually-tailored learning approach; progressive skill development and flexible training event design; integration of modern training technologies with a focus on virtual reality (VR); Small cohort classes with "detachment-style" culture (e.g., led by Officer-in-Charge, dedicated spaces for training and study). To understand the benefits of NATN and Project Avenger, Chief of Naval Air Training (CNATRA) and Naval Aviation Training Systems and Ranges Program Office (PMA-205) are

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Contents

1. List of Figures and Tables

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3. Executive Summary

3.1. Problem, Objectives, and Organization

The Department of Defense (DoD) services are exploring methods to address growing pilot shortages by re-imagining training methodologies and integrating emerging technologies to create more effective and efficient training. Falling under the umbrella term "Training Next," these myriad of efforts across the services were started by the Air Force with its experimental Pilot Training Next (PTN) program and are continuing with the Army and Navy as Aviator Training Next (ATN) and Naval Aviation Training Next (NATN), respectively. NATN implemented its first major syllabus revision in 2020 with Project Avenger (named after the aircraft flown in World War II by President George H.W. Bush). Project Avenger is a Fixed Wing Primary syllabus update employing the following novel principles:

- Competency-based, individually-tailored learning approach;
- Progressive skill development and flexible training event design;
- Integration of modern training technologies with a focus on virtual reality (VR);
- Small cohort classes with "detachment-style" culture (e.g., led by Officer-in-Charge, dedicated spaces for each class for training and study).

To understand the benefits of NATN and Project Avenger, Chief of Naval Air Training (CNATRA) and Naval Aviation Training Systems and Ranges Program Office (PMA-205) are evaluating its effectiveness and efficiency for training pilots compared to legacy-style training. This report examines the preliminary

effectiveness and efficiency of Project Avenger by comparing performance outcomes of Project Avenger student naval aviators (SNAs) to legacy syllabus SNAs. Recommendations for future iterations of Project Avenger and similar training programs are provided based on the team's analyses and SNA, Instructor Pilot (IP), and leadership feedback.

3.2. Method, Assumptions, and Procedures

Civilian Research Psychologists from the Naval Air Warfare Center Training System Division (NAWCTSD) Multidisciplinary Extended Reality (MXR) team, and active-duty Aerospace Experimental Psychologists (AEPs) from CNATRA and PMA-205 collaborated on the design of this evaluation, which includes both quantitative analyses and summaries of qualitative data. This evaluation did not require additional SNA participation outside of the training requirements set by CNATRA and therefore did not interfere with training.

The research team analyzed and compared data from two methodologies for Primary flight training: the new Project Avenger syllabus and the legacy syllabus. For Project Avenger, the research team received gradebooks for all 20 SNAs (the first class of Project Avenger), their responses to CNATRA's Avenger Student Questionnaire, and feedback data from two focus groups with IPs and leadership involved in Project Avenger. For the legacy syllabus, the team received event-level grades from the Training Integration Management System (TIMS) for 3,491 previously-graduated Primary SNAs as well as maneuver-level TIMS performance data for 1,588 Primary SNAs.

3.3. Results and Discussion

3.3.1. Performance

As the Project Avenger syllabus represents a shift from a learning objective approach (i.e., "one-size-fits-all" list of prescribed events to be completed before deemed competent) to a competency-based learning approach (i.e., event difficulty is individually tailored to maintain a constantly challenging environment and rapid syllabus completion), it was expected that Project Avenger students would have lower early scores and higher later scores than their peers. Presumably, this would be due to elevated difficulty levels in the experimental syllabus, as well as the lengthy process of habit-formation required by

Avenger's emphasis on mastery of complex mission skills. This was supported by several of the events and metrics compared between the two syllabi.

Understanding the drastic disparity in syllabus flow, stages, and event flexibility is an absolutely critical point in interpreting the performance results herein. This report examines the available metrics that lend themselves to comparison between these different syllabi. While these results will allow for trend analysis, it could be a misinterpretation of these data to conclude lower performance metrics were a sign of Project Avenger shortcomings. Although it is a possibility that these results could be a sign of syllabus limitations, other factors may have contributed to imperfect comparisons. With these notes stated, some broad performance results include:

- On overall Event Raw Score (ERS; i.e., the sum of maneuver grades across all events divided by the sum of Maneuver Item Files, or MIF), Project Avenger SNAs generally scored lower than legacy SNAs.

- During Project Avenger's "Qualification Stage", SNAs tended to receive grades lower than their legacy counterparts on early events, but outperformed legacy SNAs on some later, more complex events (i.e., formation and cross-country events) and did so with fewer prior events (i.e., less practice and experience).

- In the Project Avenger "Mission Stage" (i.e., final stage in which IPs challenge students with a variety of realistic mission deviations), the research team compared M4000 flights to end-of-block legacy flights, and M4190 checkrides to legacy checkrides. In both sets of events, Avenger SNAs showed lower grades than legacy SNAs, but also attempted more unique maneuvers on these events (i.e., greater event complexity and difficulty).

- Difficulty weightings implemented by Project Avenger, as well as difficulty-related covariates used by the researchers, did not substantially change the pattern of results. This suggests difficulty weighting should be used more aggressively or other means of accounting for difficulty should be explored; it also may indicate a need for greater change to MIFs to account for the

Mission Stage's emphasis on decision-making skills rather than maneuver skills.

In summary, although analyses tended to show higher scores for legacy SNAs, results were mixed with Avenger outperforming in some cases. Additionally, Avenger SNAs achieved similar or higher grades in fewer events, usually while attempting more unique maneuvers. This suggests that Avenger produces a stronger generalized aviator faster than legacy training.

3.3.2. Efficiency

Results show that Project Avenger was more efficient than the legacy syllabus with regard to time to train and number of syllabus events, even though the number of flight hours was similar to legacy training. Time to train was approximately six weeks shorter for Project Avenger compared to the traditional legacy syllabus, and Project Avenger SNAs required fewer flights and fewer overall events to reach the Safe-for-Solo Milestone. In addition, although Project Avenger had a large number of Immersive Training Device (ITD) events, the number of simulator events (i.e., Unit Training Device, UTD, and Operational Flight Trainer, OFT, combined) and the number of live flights were lower for Project Avenger than for legacy training, indicating again that Project Avenger was more efficient in terms of the most costly events. Compared to legacy training, Project Avenger had a similar count of all extra events, although sub-types of extra events differed between the two syllabi. Specifically, Avenger SNAs performed more reflys, but legacy training condition SNAs had more warmups, an indication that Avenger's flexibility provided greater efficiency; warmups are provided when SNAs are unable to fly within time allotments. Additionally, IPs expect to further reduce the average number of flights SNAs need to reach proficiency via more efficient flight scheduling to limit redundancies. Thus, Avenger appears to have met its goal of increasing efficiency, and is likely to further increase efficiency in future iterations.

3.3.3. Feedback

Feedback on Project Avenger during focus groups and on the Student Feedback Questionnaire was overwhelmingly positive. IPs and leadership agreed that, although it develops a SNA who is less adept at the T-6B aircraft specifically, the SNA is a much better "generalized aviator." They expect Avenger SNAs to be

able to think more critically during flight and be better able to respond successfully to unexpected contingencies. By developing generalized aviator skills to a greater extent than legacy training, Avenger is expected to better prepare SNAs for Advanced Training, which in turn will lead to better outcomes in their final fleet aircraft.

IPs and SNAs made similar remarks on the following topics:

- There is resistance to Project Avenger among non-Avenger instructors, which can be addressed by educating them about the program.

- ITDs, Project Avenger's VR trainers, were used advantageously, especially early in the syllabus. However, increasing their realism would enhance their benefit throughout the syllabus. IPs indicated the flight model as a top priority for ITD upgrades.

- The "detachment model," with its high level of IP support and student-to-student interaction, is beneficial to learning.

- Future iterations of Project Avenger should include an organized Instrument ground school to improve Instrument training.

- Pre-Flight events should be organized such that classroom training precedes ITDs, and ITDs precede simulators (SIMs).

- There is concern Project Avenger graduates could be at a disadvantage relative to their peers due to differences in grades and flight hours.

- All Project Avenger IPs and leadership, and a large majority of Project Avenger SNAs, would recommend Project Avenger for all future Primary SNAs.

3.4. Recommendations

The following changes are recommended, either directly by IPs and SNAs, or by the MXR team summarizing the quantitative results and qualitative feedback. Additional recommendations have been identified by CNATRA in their own report.

Infrastructure and Technology Upgrades:

- Ease instructor administrative workload by providing Avenger-designated Student Control (STUCON) personnel and by providing a usable and portable Learning Management System (LMS).

- Enhance the detachment (det) space by moving at least one ITD and some VR headsets into the shared space to facilitate learning via greater usage, student collaboration, and IP discussions.

- Expand communication practice availability. Explore extending the student capacity and hours of commercially-available mock Air Traffic Control (ATC) capability (e.g., PilotEdge) or integrate synthetic ATC options to enhance access for student practice.

- Upgrade the ITDs with a more accurate flight model, more accurate trim characteristics, and replica hands-on throttle and stick (HOTAS), as well as more reliable software.

- Identify methods for improving simulated formation flight practice, such as ITD upgrades to improve visual fidelity, UTD upgrades with augmented and/or mixed reality headsets, and/or connecting UTDs or OFTs to enable formation flights.

- Address needed infrastructure and cybersecurity changes as soon as possible to support a scaled-up version of Project Avenger.

Grading and Instruction:

- Create a unique grading metric for Project Avenger that prevents unrealistic comparison of Project Avenger performance scores to the legacy syllabus metric (i.e., the Navy Standard Score, NSS), possibly including more aggressive difficulty metrics and/or additional weightings based on number of maneuvers or critical thinking performance. As Project Avenger matures, an Avenger-specific, norm-referenced, and difficulty-weighted metric should be developed that is validated against Advanced Training performance.

- Until a valid and reliable Avenger-specific performance metric is established, create Advanced pipeline selection processes that do not require minimum NSS (e.g., selection for Strike pipeline currently required NSS ≥ 50 in legacy syllabus). If legacy selection methods are used while Avenger lacks a sufficient norm group, fully capable students could be inappropriately disqualified from competitive training pipelines that require a minimum NSS.

- Treat SIM events as guided practice rather than an evaluation of performance; SIMs should stress learning, encourage SNAs to challenge themselves, and facilitate questions and discussion. Events should still be graded, but grades should be used as feedback tools on what and how to improve.

- Improve training efficiency by reducing redundant Special Syllabus Requirements (SSRs). Two potential methods to assist are assigning Mission Stage partners so that SNAs complete the same SSRs or standardizing the Mission Stage syllabus to include similar events.

- Clarify the Master Curriculum Guide (MCG) by breaking down requirements by Stage and addressing inconsistencies with the gradebook.

- Investigate processes to prevent Project Avenger SNAs from missing career milestones or opportunities by redesigning aircraft commander ratings to account for fewer flight hours in Project Avenger.

- Train instructors on Project Avenger objectives and structure and, when possible, schedule Avenger SIM and flight training events with outside instructors prior to SNA performance assessments or as an observer to enhance understanding of the program and eliminate misconceptions.

Content and Timeline:

- Improve the “crawl-walk-run” syllabus flow for Day Contact and aerobatic maneuvers.

- Increase the amount of angle of attack (AoA) approach training to address requests from the tailhook community.

- Add a brief introduction to paper charts to ensure SNAs are prepared to use them.

- Upgrade Instrument training by developing a more robust Instrument ground school.

- Ensure students prioritize appropriate events by separating Safe for Solo and the initial Instrument SIM event.

- Use the legacy syllabus's Visual Flight Rules (VFR) lab on Vertical Navigation (VNAV) planning to improve SNA knowledge and understanding.

From the above recommendations, it is evident Project Avenger warrants further iterative development before full-scale replacement of the legacy syllabus. However, despite certain areas that require additional refinement, IPs and SNAs in the program provided consistently high praise for the new approach; specifically, its flexibility, accessibility to training devices, detachment culture, and critical thinking outcomes were held in high regard. Efficiency and effectiveness data also show promise for outpacing legacy performance outcomes, but follow-on analyses will need to be conducted as the first classes complete Advanced training. Due to the small sample size from Avenger, the research team did not analyze cost savings, but will do so when more classes are complete and a more accurate assessment is possible.

4. Introduction

4.1. Problem

There is a shortage of pilots across the military services of the Department of Defense (DoD). For example, the Navy had a 26% shortage in first-tour fighter pilots as of 2017 (United States Government Accountability Office, 2018). One of the primary causal factors is pilot training pipelines are not producing pilots quickly enough to cover the United States Military's needs. Training pipeline throughput needs to be increased to mitigate current and forecasted shortages, but must also take into account the limited resources available. One method for addressing this issue is to focus on increasing the efficiency and effectiveness of pilot training.

Project Avenger serves as an update to the Primary Fixed-Wing syllabus. Chief of Naval Air Training (CNATRA) and Naval Aviation Training Systems and Ranges Program Office (PMA-205) are evaluating NATN's effectiveness and efficiency compared to legacy-style training. The Multidisciplinary Extended Reality (MXR) research team at the Naval Air Warfare Center Training Systems Division (NAWCTSD) conducted this initial, cross-sectional evaluation, which examines the effectiveness of NATN's Project Avenger as compared to traditional naval aviation training.

4.2. Objectives

The purpose of this study was to assess the impact of Project Avenger on Student Naval Aviator (SNA) performance outcomes and training efficiency within Primary training and develop recommendations for future iterations of Project Avenger. Specifically, the research team compared performance metrics from the first class of Project Avenger (September 2020 – March 2021) to performance metrics from SNAs in legacy training. Additionally, the research team analyzed SNA responses to CNATRA's Project Avenger student feedback questionnaire and conducted a focus group to collect qualitative feedback from instructors and leadership involved in Project Avenger.

4.3. Background

Project Avenger is leveraged from the Air Force's Pilot Training Next (PTN) exploratory program and the Banzai Flight syllabus

program "to produce a more capable and self-sufficient aviator, proficient in dynamic and fluid environment; and to do so more efficiently than we do today" (Friel, 2020a).

Air Force Pilot Training Next

To investigate efficiency and effectiveness improvements to training, the Air Force developed the PTN program, an exploratory program for examining a range of experimental options to move trainees through the pilot training pipeline more quickly. In the PTN syllabus, Virtual Reality (VR) flight trainers were employed as much as possible in place of live flight, aircraft availability was increased to reduce availability-based delays in training, and the number of instructors was increased such that there were roughly 1.5 to 2 students per instructor rather than the traditional 4-8.

Although the first iteration of the Air Force's PTN exposed some technical difficulties, including scheduling complexity inherent in a more flexible syllabus, limitations in a virtual tutor, and fidelity problems in the VR flight trainers (Lewis & Livingston, 2018; SAIC, 2018), evaluations of PTN indicate it can successfully produce graduates in a shorter amount of time than legacy training. Thirteen of the 20 students in the first PTN class completed the PTN program in 6 months, whereas the legacy program takes a year to complete (Lewis & Livingston, 2018; SAIC, 2018). PTN version 1 students also required fewer live flights to reach their first successful solo flight than legacy students (Lewis & Livingston, 2018). PTN Version 3 showed greater success in syllabus completion than Version 1. Even with limits on aircraft and instructor availability, the use of VR flight trainers known as Immersive Training Devices (ITDs) and an updated syllabus enabled the Air Force to graduate participants after fewer flights and with fewer flight hours than legacy trainees, at similar levels of skillset proficiency, and with a comparable attrition rate. This occurred in spite of fidelity issues in the ITDs that placed some limits on their ability to replace live flights (19AF Detachment 24, 2020).

Air Force Undergraduate Pilot Training 2.5 "Banzai"

While the experimental PTN program is not scalable to the entire Air Force's flight training program, the Air Force used PTN's successes to create the Undergraduate Pilot Training (UPT) 2.5 syllabus, or "Banzai". Banzai Flight was a "scaled down test

group within the Air Force's UPT program to redesign and test a new training syllabus that has the following premises: (a) "time is no longer a constant, COMPETENCE is, (b) give students total control (on command, on demand), and (c) develop 'Creative Thinkers in the Art of War'" (Friel, 2020a, p. 8).

Banzai (UPT 2.5) differs from traditional training in several ways (Lewis & Livingston, 2018; SAIC, 2018). First, it uses a flexible schedule based on student readiness and weather allowance rather than the more rigid calendar-based schedule of legacy training. Second, classroom content is condensed to increase time for active practice, often in VR, with some sessions being coached by an IP or leveraging live air traffic controllers in VR for communication practice. Third, Banzai integrated a "crucial element" of PTN (Lewis & Livingston, 2018, p. 4): heavy utilization of ITDs, small-footprint virtual reality flight simulator (SIM) devices built from commercial off-the-shelf (COTS) hardware. ITDs have much higher availability for student practice than the legacy flight simulators and enable "buddy" practice with another student or instructor. Additionally, they enable immediate practice of skills learned in the classroom. There is also a cultural aspect of Banzai that cannot be ignored as an instrumental feature. Each Banzai class, called a "Flight" by the Air Force, was assigned dedicated IPs to that specific class to assist with training needs and be present and available for questions. This increased student-IP interactions, building familiarity and comfort between them and creating a more team-oriented and conducive learning environment.

Naval Aviation Training Next: Project Avenger

With the initial results and lessons learned from PTN and Banzai, the Navy developed NATN's Project Avenger. Project Avenger is the first syllabus launched as part of NATN, with its inaugural class starting in September 2020; it is specific to the Fixed-Wing Primary syllabus, the initial flight training in naval aircraft for future naval aviators. Project Avenger's objective is to reduce time-to-train in Primary flight training from the 6-8 months scheduled in the current (legacy) syllabus down to 4-5 months, while also improving the quality of its graduates. This reduction in time is especially important because though the legacy schedule calls for Primary completion in 6-8 months, in practice it often ends up being weeks to

months longer due to various delays (e.g., resource constraints, weather, scheduling inefficiencies, etc.).

To reduce time to train, Project Avenger leverages lessons learned from the Air Force. These lessons include the following:

- Extensive access to VR devices for self-practice;
- 24/7 access to course content (e.g., flight publications, lectures, videos);
- Instructors scheduled to be on-site and readily available for discussion;
- Training cohorts with dedicated instructors; and
- Focus on the detachment-style culture.

In the Navy's legacy Primary syllabus, despite each SNA being part of a class, they are more isolated due to training at varying paces based on varying flight schedules, typically with a brief, non-local training site "detachment" at some point during training. "Detachment," in this case, refers to a group or class of students who train closely together and have their own local leadership (i.e., Officer-in-Charge and Assistant) and dedicated space; this is very similar to the "Flights" employed by Banzai. The dedicated space for the SNAs is where briefs and debriefs often occur, television screens are mounted to broadcast briefs and training, and SNAs have access to computers for study purposes. In legacy training, detachments are used for non-local, off-site training, whereas Project Avenger utilizes this detachment model throughout Primary training to encourage SNA-IP interaction, peer-to-peer teaching and learning, and the development of camaraderie and a team mentality.

Beyond technologies used in the legacy syllabus (e.g., operational flight trainer, OFT), Project Avenger utilizes new technologies (e.g., ITDs, iPads) to facilitate learning, a syllabus individually tailored to the strengths and needs of the SNA, and a grading system meant to encourage SNAs to challenge themselves. Project Avenger also employs a somewhat higher ratio of instructors to students than traditional training, with seven full instructors and four associate instructors for the first

class of 20 SNAs. Differences between the Avenger and legacy syllabi are outlined in Table 1.

Table 1. Expected differences in training syllabi

	LEGACY T-6B SYLLABUS		PROJECT AVENGER T-6B SYLLABUS	
Expected Time to Train:	6-8 months		4-5 months	
Training Device:	Events	Hours	Events	Hours
Unit Training Device	12	15.6	5	6.5
Operational Flight Trainer	24	31.2	11	14.3
Instrument Flight Trainer	N/A*	N/A*	13	16.9
ITD with Instructor Pilot	N/A	N/A	29	25.0
Solo practice in ITD	N/A	N/A	36	26.4
DEVICE TOTAL:	36	46.8	94	89.1
Aircraft Event:	Events:	Hours:	Events:	Hours:
T-6B Dual	44	71.5	44*	68.9**
T-6B Solo	3	4.6	4*	6.0**
AIRCRAFT TOTAL:	47	76.1	48*	74.9**
Training Strategy:	Description:		Description:	
Culture	Individual SNAs train at different paces based on flight scheduling		Detachments with assigned instructors train together	
Syllabus Flow	Same for all SNAs		Tailored to individual SNAs	
Maneuver Difficulty	Same for all SNAs		Set by individual SNAs and instructors	
iPad Usage	N/A		iPad issued to each SNA for on-demand learning	
SNA-to-Instructor Ratio	Between 4:1 and 8:1		3:1 (goal of 4:1)	

*Note: Some legacy events have the option to be completed in either the Instrument Flight Trainer or one of the higher fidelity trainers (i.e., Unit Training Device or Operational Flight Trainer). Whenever possible, the higher fidelity trainers are used.
**Note: These are the maximum numbers of syllabus events a student can complete in Avenger to reach required proficiency. However, students are progressed at the pace of skill acquisition and are expected to complete the syllabus in fewer events/hours.

4.3.1. Project Avenger Technology

The Project Avenger syllabus utilizes multiple different media to progress SNAs through the T-6B training pipeline. To begin training, SNAs spend a set number of hours receiving face-to-face classroom instruction from an IP using PowerPoint and videos. To enhance self-study outside the classroom, each SNA is issued an iPad (Apple Inc., Cupertino, CA) and an Oculus Go headset (Oculus, Menlo Park, CA). These are not issued in legacy training, which instead relies on traditional paper publications. Through the iPad, SNAs have portable, 24/7 access to electronic copies of documents such as technical manuals. They also have access to 360 Videos (videos demonstrating flight skills with a 360-degree field of regard) both in the Oculus headset and on the iPad, as well as instructional videos previously unavailable to legacy SNAs (videos were made available to all SNAs, Avenger and legacy, as they were completed and uploaded).

Project Avenger also provides and employs a variety of additional software applications to facilitate student learning that are not "officially" present in the legacy syllabus, but can be purchased and utilized by the individual SNAs. Most frequently used applications include ForeFlight, CloudAhoy, and PilotEdge. ForeFlight (ForeFlight, Houston, TX) is a flight-planning software provided to Project Avenger SNAs for planning flights, accessing flight publications in flight, real-time weather monitoring, and traffic advisories (LCDR K. Bistline, private communication, 10 May 2021). CloudAhoy is a flight logging and debriefing tool (CloudAhoy, Lexington, MA), to help students visualize flight performance. PilotEdge provides air traffic control (ATC) simulation using live air traffic controllers (PilotEdge, Pompton Plains, NJ) paired with the ITDs to simulate and allow practice of communications with ATC and other pilots.

Finally, Project Avenger SNAs have the ability to interact with simulators (SIMs) such as ITDs, unit training devices (UTDs), and operational flight trainers (OFTs). These simulators are employed in Project Avenger for training events with instructors, scheduled practice in the absence of an instructor, and self-guided practice during free time.

ITDs are desktop computers configured with head mounted displays, flight controls (control stick, throttle, and rudder pedals), flight simulator software, and a flight model of the necessary aircraft (in this case, the T-6B Texan II). See Figure 1 for an image of the ITD used in Project Avenger.

Figure 1. T-6B Immersive Training Device

The UTDs, used in both syllabi, are employed in Project Avenger for instrument training with an instructor, and are also available for self-study when not in use for syllabus events. The UTDs originally consisted of a fabricated cockpit with moveable controls, and are used in the legacy syllabus for instrument and procedural training not requiring external visuals. For Project Avenger, television monitors were also added to the UTDs to provide forward visuals, with the intention of increasing training capabilities and improving SNA awareness of the external environment (Figure 2).

Figure 2. Unit Training Device (UTD) with on-screen visuals

OFTs (2F138D models) are employed in training events with an instructor, and are the same devices used in legacy training. They are bespoke systems developed specifically for CNATRA's training purposes, and include a replica of the T-6 cockpit, a projection screen for visuals outside the cockpit, and an instructor station from which the instructor loads training scenarios and monitors performance.

Finally, CNATRA provides access to Stratus Automatic Dependent Surveillance – Broadcast (ADS-B) receivers (Appareo, Fargo, ND), which provide weather and traffic updates. Although they are available for legacy SNAs, they are not trained to use the Stratus receivers, whereas SNAs in Project Avenger are trained to use them.

Table 2 provides a list of the specific technologies utilized by each syllabus. A discussion of the advantages of enhancing student aviator practice with extended reality (XR) systems such as the ITDs can be found in McCoy-Fisher et al. (2019), which includes an evaluation of an older version of the T-6B ITDs as well as three other XR flight trainers.

Table 2. Technology used as components of the syllabi

Technology	Legacy Syllabus	Project Avenger
Paper Publications	**Yes**	**No**
Computer Assisted-Instruction (CAI)	**Yes**	**Yes**
360-degree Videos	**No***	**Yes**
iPad	**No***	**Yes**
Oculus Go	**No**	**Yes**
ForeFlight	**No****	**Yes**
CloudAhoy	**No****	**Yes**
ADS-B	**No**[+]	**Yes**
PilotEdge	**No**	**Yes**
Instrument Flight Trainer (IFT)	**Yes**[O]	**Yes**
ITD	**No**	**Yes**
UTD	**Yes**	**Yes**
OFT	**Yes**	**Yes**

*Legacy SNAs can use personal tablets, but are not issued a tablet, and have access to the 360-degree videos though they were only recently created.
**ForeFlight and CloudAhoy are available for legacy SNAs to use via personal accounts on personal devices, but are not a part of the legacy curriculum.
[+]ADS-B devices are available for legacy SNAs and IPs to check out, but are not a part of the curriculum and are not used.
[O]The IFT is only used in legacy training when higher-fidelity trainers are not available.

4.3.2. Project Avenger Syllabus

The Project Avenger syllabus flow is presented in Appendix 1. The syllabus is designed for compressed delivery through a flexible flow through two primary methods:

1. Rather than completing a set number of events, SNAs are able to advance to the next group of events once IPs deem them proficient across specified skillsets ("proficiency advancing").

2. SNAs can complete events "out of order" from other training blocks (e.g., formation or navigation) to reduce delays due to conditions such as poor weather.

In addition, the syllabus is designed to incentivize SNAs to challenge themselves and learn from mistakes more than the legacy syllabus. Specifically, SNAs and IPs can increase the difficulty of an event and the IP can weight the grade accordingly to reward SNAs for attempting difficult maneuvers or events. Though several items are prescribed, SNAs have flexibility to choose, with IP concurrence, specific skills they want to focus on in a given syllabus event. SNAs are also allowed to progress even if unable to demonstrate proficiency for a maneuver on a specific flight, provided they still have follow on flights in which they could reach proficiency in that skill. In other words, in legacy training, certain levels of proficiency have to be reached within specific blocks of training to progress; while in Avenger, they can utilize multiple blocks to reach the necessary level of proficiency for any specific maneuver as long as other areas are continuing to progress. This flexible approach allows students more opportunities to practice items needing improvement and accelerate through sections in which they excel.

The Project Avenger syllabus features three Stages: (1) Pre-Flight, (2) Qualification, and (3) Mission. Unlike the legacy syllabus's block approach, in which skillsets are often learned, completed, and then not attempted again in subsequent training blocks (increasing risk of skill decay), Project Avenger SNAs are expected to maintain their readiness to perform skills learned in one stage throughout the rest of the syllabus.

Pre-Flight includes academics and simulation events that provide the conceptual knowledge and fundamental procedures for flight

training. This stage must be completed before event number Q4T01, the first live flight event focused on basic flight procedures. The objective of the Pre-Flight Stage is for SNAs to establish a self-motivated approach to learning content from CAI, iPad (document access and videos), 360-degree goggles, ITD, UTD, and OFT. The Pre-Flight Stage is broken into two sections: 1) a Pre-Requisite section and 2) a Pre-Flight preparation section covering contact and basic instruments information. This is a change from legacy, in which contact and basic instruments are covered sequentially instead of concurrently. Earlier instruction on instrument flying increases training efficiency by decreasing weather-related flight cancellations in which instrument skillsets are required for safety of flight.

The Qualification Stage focuses on providing an introduction to maneuvers and basic airmanship proficiency in all major blocks of flying covered in the legacy syllabus. This stage has three sections: Transition (a combination of the legacy contact and instruments phases), Navigation, and Formation. The Qualification Stage is intended to introduce all aspects of flight, provide opportunities for practice and skill development, and create a student with a level of proficiency to be safe across all types of flight, but not the level of proficiency required to graduate (though a student could excel and reach this level).

The Mission Stage contains entirely new types of events and was developed to improve the holistic performance of students by bringing all previously learned skillsets together as a whole. It does not have an equivalent in the legacy syllabus. By combining the skills learned during the Qualification Stage (Transition, Navigation, and Formation) into realistic events, the Mission Stage events resemble real flight operations that SNAs will experience in the Fleet. Unlike the legacy's rigid checkrides, which focus on specific skills within a single block of training, a major focus of the Mission Stage is to develop adaptability to changing situations and be able to handle contingencies, planned and unplanned, appropriately. The goal is to create pilots with "better situational awareness, decision-making, mission planning, execution/profile management, and fuel and time awareness"; skillsets transferable across aircraft instead of T-6-specific proficiency (Friel, 2020b, p. 7).

Project Avenger's new syllabus design is meant to capitalize on findings from research on habit formation and developing skill mastery. Research on habit formation shows that it can take

approximately six months to develop complex behavior habits (Lally, Van Jaarsveld, Potts, and Wardle, 2010). Through early introduction and repetition of skillsets across more events throughout the entirety of the syllabus, Avenger is structured to provide the time necessary to develop stronger habits around the skills necessary for aviation. Legacy training, however, is built to maximize performance in a shorter time period, typically two months or less(i.e., within a single training block), and does not afford what research shows as necessary time and repetition for development of complex habits and long-term retention. In conjunction with this, research shows that introducing situational variability while learning skillsets provides stronger learning and development of skill mastery than focusing on single skillsets in the same situation or environment (Bjork & Bjork, 2019; Lee & Magill, 1983; Shea & Morgan, 1979). By encouraging SNAs to challenge themselves throughout training and using different flight profiles in the Mission Stage, Avenger introduces more variability to improve learning and skill mastery. Although the legacy syllabus may reach higher performance in the short term due to a narrow focus in a short period of time via its block approach, Avenger's syllabus should develop stronger habits and greater skill mastery leading to better long-term performance by leveraging scientific research.

4.3.3. Project Avenger Grading System

Project Avenger leverages the legacy grading system, but adds in aspects from the Banzai syllabus's grading to help motivate students to challenge themselves as well as identify any trends in why a student may be struggling. The traditional grading employed by both the legacy syllabus and Project Avenger is the Multiservice Pilot Training System (MPTS), which uses a standard passing grade to be achieved for each maneuver (the Maneuver Item File or MIF), and the grade received is compared to the MIF. The overall grade for an event, known as an Event Raw Score (ERS) is equal to the sum of grades received divided by the sum of the associated MIFs. This results in scores nested around one where below 1 corresponds to below the minimum level of performance required, 1 indicates meeting minimum performance required, and above 1 indicates above-adequate performance.

Beyond the legacy grading, Project Avenger allows instructors to weight the difficulty level of the maneuvers to reward students for challenging themselves instead of only doing what is easy to ensure good grades. Weightings are applied after the maneuvers

are performed, when the instructor grades the SNA's performance. For each maneuver, there are four difficulty levels: -1 ("Too easy"), 0 ("Normal"), 1 ("Hard"), and 2 ("Yikes!"). For any given event, the weighted ERS is calculated as:

$$\frac{Sum\ of\ Maneuver\ Grades + (Sum\ of\ Difficulty\ Levels/2)}{Sum\ of\ MIF}$$

For example, if an SNA completed an event in which the sum of their maneuver grades was 9, and the sum of grades need to pass maneuvers was 10, then their ERS without considering difficulty level would be 9/10 = 0.9, a lower-than-adequate score. However, if three of their maneuvers were rated as "Hard" (a numerical rating of 1), then their weighted Event Grade would be:

$$\frac{9 + (\frac{3}{2})}{10} = 1.05.$$

Thus, SNAs can be rewarded for challenging themselves with high-difficulty maneuvers. It is important to note assigning a difficulty level is at IP discretion.

In addition to weighting event grades, Project Avenger includes qualitative feedback in its grading system. Gradebooks contain the option to include root cause analysis of issues in completing maneuvers, with knowledge, decision, perception, and execution as potential root causes:

- Knowledge: poor understanding of how to conduct the maneuver.
- Decision: choosing the wrong action.
- Perception: failing to perceive relevant information inside or outside the cockpit correctly.
- Execution: making the correct decision but failing to execute it correctly.

Finally, like legacy training, Project Avenger gradebooks include a section for comments but with additional guidance to focus it as a post-requirement guide for each event. In this section, the instructor provides written guidance for addressing weaknesses in event performance, such as assigning additional

practice or recommending changes to practice techniques. For this evaluation, the primary interest was in the effectiveness of Project Avenger as a training system compared to traditional training; therefore, only the quantitative grades were employed in performance analyses.

4.3.4. Research Questions

To examine if the Avenger approach is more effective than the traditional approach in preparing SNAs for flight events, the research team conducted an evaluation to compare SNA performance in both syllabi. This evaluation examined the first iteration of Project Avenger, which ran from September 2020 through March 2021. The first class of Project Avenger totaled 20 SNAs (including one attrite, where "attrite" refers to SNAs who discontinued training). No special performance criteria were used for SNA selection; the only criteria for the first class of Project Avenger were that it include women and Marine Corps trainees.

Specifically, the following questions were examined:

1. How do performance outcomes (ERS) differ between Legacy and Project Avenger SNAs?
2. How does training efficiency (time to train and number of events) compare between Legacy and Project Avenger SNAs?
3. How do technologies and training methods impact Project Avenger training?
4. What are the perceptions of Project Avenger adoption?

To address performance differences, event grades were statistically compared between two groups: SNAs from the first class of Project Avenger (experimental group) and SNAs who completed Primary training using the legacy Fixed-Wing Primary syllabus, CNATRAINST 1542.166B (CNATRA, 2017).

It was expected that Project Avenger SNAs would have lower grades than legacy SNAs, due to its focus on competency-based learning (i.e., event difficulty is individually tailored to maintain a constant challenge and rapid syllabus completion, and events are designed to emphasize mastery of complex mission skillsets) rather than legacy's learning objective focus (a prescribed list of events completed in the prescribed manner as

a demonstration of "proficiency" on a technical skillset). Additionally, Avenger's earlier, broader, and more flexible skillset introduction and with longer repetition cycles were expected to facilitate more masterly learning over legacy's block approach in which a minimal number of skillsets are practiced until proficient before moving to the next. As found by Lally, Van Jaarsveld, Potts, and Wardle (2010), complex habits (e.g., those required for flying) take up to six months to establish, indicating that Avenger's approach of emphasizing skillset practice across the entirety of the syllabus rather than only in its specific block may be more likely to generate habit formation. However, spreading out the practice across a syllabus instead of narrow, frequent practice to demonstrate proficiency suggests that early Avenger grades should be lower than legacy because Avenger SNAs are not mastering the skills until the later stages of the syllabus.

For efficiency, the time between the first simulator event and the last flight, as well as numbers of events, were compared between the same two groups of SNAs. Qualitative data were summarized to gauge the impact of technology and training methods on Project Avenger and the perceptions of the program by the SNAs and IPs who participated in the study.

Other quantitative analyses and summaries of feedback were conducted to expand on legacy vs. Avenger differences and assist CNATRA and other military leadership in pinpointing areas to improve future iterations of Project Avenger, provide lessons learned for other training programs, and inform future acquisition decisions.

5. Methods, Assumptions, and Procedures

5.1. Methods

Per the Department of the Navy Human Research Protection Program (HRPP), the institutional review board (IRB) at NAWCTSD reviewed and approved this evaluation as human subjects research. The IRB determined that it fell under the classification of exempt research and met the ethical standards for exempt human subjects research.

5.1.1. Participants

Student Naval Aviators

This evaluation examined the first class of Project Avenger: 20 SNAs at Naval Air Station (NAS) Corpus Christi (14 Navy, one female / 13 male; 6 Marine Corps, one female / five male). Of the 20, 19 completed training and one attrited due to medical concerns. Data collected from this group included performance data from the Project Avenger student gradebooks and responses to a feedback questionnaire required by CNATRA as a part of the Project Avenger syllabus.

CNATRA provided the research team with two sets of Training Integration Management System (TIMS) performance data from the legacy syllabus. One set contained data on individual maneuvers for 1,588 SNAs (1,495 from Training Wing 4, 93 with no Training Wing affiliation listed; no gender data provided; 173 attrites). The second set contained ERS from each event for 3,491 SNAs (1,497 from Training Wing 4, 1,994 from Training Wing 5; no gender data provided; 306 attrites).

The SNAs in the two data files overlapped heavily, but not entirely. The maneuver-level data file contained 93 SNAs who were not included in the event-level data; and, due to the larger number of SNAs included in the event-level data file, it contained 1,991 SNAs who were not in the maneuver-level data.

Instructors and Leadership

Instructors and leadership were invited to participate in a focus group to discuss successes and recommended improvements for Project Avenger. The focus group included nine participants (all male) who were involved in the first class of Project Avenger.

5.1.2. Materials and Apparatus

Towards the end of the first class of Project Avenger, a set of Focus Group Questions were distributed. CNATRA's Avenger Student Feedback Questionnaire, which was included as a requirement in the syllabus, was also leveraged.

Student Feedback Questionnaire

The team received SNA feedback from the 32 questions developed in-house by CNATRA (presented in Appendix 2) to examine trends

in responses. The questionnaire contains a mix of 6-point Likert-type questions (scaled from 1 to 6), free response questions, and a few multiple-choice questions. It is broken up into five sections covering SNA demographics and four aspects of training: *Rating of Course Materials*, *Rating of Content & Delivery*, *SIM & Flight Instructors*, and *Summary Feedback*.

- *Rating of Course Materials* focuses on the quality of course materials, requesting SNAs to rate the various materials provided as well as answer free response questions regarding which were most and least beneficial and what the SNA would change about the course materials.

- *Rating of Content & Delivery* focuses on the quality of the content and the type of delivery method utilized (e.g., lectures, simulators, practice with or without an IP). SNAs are asked to rate the training on aspects such as effectiveness and understandability as well as answer free-response questions on which aspects of the training were most and least beneficial and what the SNA would change about delivery methods.

- *SIM & Flight Instructors* focuses on the quality of instruction received from both SIM and flight instructors. It also includes free response questions regarding instructional effectiveness and what instructors should change to improve training.

- *Summary Feedback* provided an opportunity for SNAs to provide any additional comments about Project Avenger.

Focus Group Questions

The focus group questionnaire consisted of a set of 16 questions (see Appendix 3) given to IPs and stakeholders to obtain their feedback on Project Avenger. These open-ended questions focused primarily on the following areas: benefits and challenges of the new syllabus; potential impacts to current instructional strategies; and suggestions for improvements to future iterations of Project Avenger.

5.2. Assumptions

This study had no impact on the training schedule or the syllabus of Project Avenger or legacy training. Data taken from

SNAs were collected as a part of the ordinary grading and feedback process used by CNATRA. It was also assumed self-study on 360 videos, iPads, and VR systems involved deliberate study rather than idle play.

5.3. Procedures

Study Design

Participants were given copies of the Privacy Act for review and the Informed Consent Document (ICD) to read and sign, and given an opportunity to ask questions. The ICD explained how their data would be used and protected, as well as the tasks they would complete. All SNAs voluntarily participated.

Performance analyses were conducted to compare Project Avenger SNAs to former SNAs who completed legacy training. For both groups, the research team used data collected in the ordinary course of training; no changes to the training schedule or other interventions were employed for this study.

As a part of the Project Avenger syllabus, SNAs were required to respond to a Project Avenger feedback survey three times, once after each stage: Preflight, Qualification, and Mission (completion of training). Despite being required, not all SNAs completed each iteration of the survey, but each iteration was completed by some of the SNAs. As with performance data, the survey was a part of CNATRA's requirements and did not require any changes to the training schedule to accommodate the research team.

Toward the end of the first class, instructors and leadership associated with Project Avenger were invited to participate in a focus group via teleconference. The focus group questions were sent out in advance to give participants an opportunity to provide initial responses in writing prior to the teleconference and allow the researchers to focus discussion on areas needing clarification or further explanation. Two teleconferences, approximately 2 hours each, were conducted, with six participants in Session 1 and 3 participants in Session 2.

Analysis

All data analyses were conducted in IBM SPSS Statistics 26 for Windows (IBM, Armonk, NY) with default settings. A two-tailed alpha level of .05 was used for significance in all analyses.

Due to considerable differences between Avenger syllabus events and legacy syllabus events, grade analysis included two main approaches to enable performance comparisons at multiple points in training:

- The first approach involved event-level performance for a set of events that instructors indicated as comparable between Project Avenger and the legacy syllabus (Table 3). These events all occurred during the Qualification Stage of Project Avenger. However, the Mission Stage is the most critical for performance, because it showcases an SNA's ability to put together previously learned skills to accomplish flexible problem solving.

- Since there is no equivalent to the Mission Stage in the legacy syllabus, a second approach to grade analysis was developed. Maneuvers were isolated from the Mission Stage M4000 flights and end-of-block flights from all four main blocks of the legacy syllabus. From these events, the research team utilized two sets of maneuvers to artificially create comparison events: one comparison set used only the maneuvers similar in both the legacy and Avenger syllabus; and the other set using all maneuvers from the relevant events, regardless of similarity between syllabi. The same approach was used to compare Mission Stage Checkrides to legacy Contact and Instrument checkrides. By combining the individual maneuver grades to create artificial late-block legacy grades and artificial Mission grades, the research team was able to form an approximate performance measure to compare the two syllabi.

Due to violations of normality and homogeneity of variance, Mann-Whitney *U* tests were used in both approaches to compare Avenger and legacy syllabus grades. See Table 3 for lists of pre-Mission Stage and Mission Stage comparison events.

When feasible, additional analyses were performed using the number of new maneuvers attempted in each event and/or number of prior events as covariates. These analyses were conducted in consideration of Avenger's flexibility, its goal of encouraging SNAs to challenge themselves, and its expectation that SNAs would reach milestones in fewer events. Additionally, at the instructor's discretion, any maneuver can be attempted in any event, so Avenger SNAs might be driven to attempt more new maneuvers than their legacy counterparts, which in turn could affect grades negatively from students attempting maneuvers for which they may not be fully prepared (and therefore receive

lower grades). Quade's Analysis of Covariance (ANCOVA) was employed for these analyses.

Table 3. Comparison events in legacy and Avenger syllabus

Event Significance	Legacy Syllabus Event(s)	Project Avenger Event(s)
Final simulator event before flights	C3101/C3102	Q3101
First flight	C4101	Q4T01
Pre-solo flight	C4304	Final Q4T event (Q4T04 – Q4T14; depends on individual proficiency)
First cross-country flight	I4301/I4302	Q4N01/Q4N02
First formation flight	F4101	Q4F01
Fourth formation flight	F4104	Q4F04
Advanced flights (legacy) compared to Mission Stage (Avenger)	C4603, C4604, I4304, I4305, N4201, N4202, F4301, F4302	All M4000-level events (up to M4015; depends on individual proficiency)
Checkrides	C4490, C4790, I4490	M4190A and B

In addition to grades, the research team conducted several comparisons, using Mann-Whitney *U* tests, to examine efficiency of the two syllabi. First, time to train (number of months between the first simulator event and the final flight) was compared. Next, the research team compared numbers of events completed, including overall number of events, flights only, and various simulator events. In addition to these comparisons, the research team examined the number of extra events completed

between legacy and Avenger SNAs, although statistical comparisons were not employed for extra events.

For the Student Feedback Questionnaire, the team used median and interquartile range to determine trends in responses to the Likert-type questions, percentages to determine trends in response to the question: "Would you recommend Project Avenger training to other students (over legacy training)?", and counts to determine common responses to the free-response questions. Focus group responses are summarized in this report without further quantitative analysis.

6. Results

For analyses of grades and efficiency, only SNAs who completed Primary training are included. Numbers of participants vary between statistical analyses due to the exclusion of SNAs with missing or incomplete data relevant to each analysis being conducted. Because Project Avenger only had one trainee attrite from the program due to medical concerns, attrites were not statistically compared between syllabi. All responses to the student feedback questionnaire are included in feedback results; because the questionnaire preserved anonymity of the respondents, it is not known if the SNA who left Project Avenger provided any responses.

6.1. Grades

Please note, due to violations of normality and homogeneity of variance in grades for both Avenger and legacy data, nonparametric analyses were required: Mann-Whitney U tests were employed for initial comparison analyses, with ERS as the dependent variable and group (legacy vs Avenger) as the independent variable, and Quade's ANCOVA was utilized to examine potential covariate effects. Although the sample size of Avenger SNAs was small (n = 19), these tests were chosen as the most reliable methods to determine statistical significance given the nature of the data, but unfortunately cannot provide all information that may be of interest. Specifically, with Quade's ANCOVA for controlling variance due to a covariate, the analyses only provide whether mean differences become non-significant; they do not provide information on the degree to which adjusted means may change. Two primary covariates are investigated in this report:

- *Maneuvers*: the number of maneuvers attempted (unique and total) are used in several analyses as a proxy for difficulty. It is assumed that SNAs attempting more maneuvers are challenging themselves to a greater extent than those who attempt fewer. This is because attempting more can make it more difficult to achieve high grades on any single maneuver.

- *Events*: the number of events (prior and total) are used in several analyses as a proxy for experience or practice. It is assumed that a higher number of events allows for more practice and will lead to higher grades than if SNAs were not afforded those attempts. However, it should be noted that due to Project Avenger's focus on progressing SNAs displaying proficiency, high-performing SNAs likely complete fewer events while lower-performing SNAs are provided additional opportunities to reach necessary proficiency.

The data referred to as "grades" are ERS, for which a value of less than 1.00 indicates below the minimum threshold of performance, 1.00 indicates meeting minimum performance requirements, and greater than 1.00 indicates above-adequate performance. For each comparison, results are reported from both Avenger ERS weighted by maneuver difficulty as described in Section 3.3.3, "Project Avenger Grading System," and Avenger ERS unweighted by difficulty (ERS calculated in the same way as legacy ERS). Cases with missing data were excluded from analysis.

However, use of the difficulty weights was unexpectedly rare (M = 17.00 non-zero maneuver difficulty weights per SNA from all maneuvers in all events in the syllabus, SD = 8.67). As an alternative, the number of new maneuvers attempted (i.e., maneuvers never graded for that SNA in any previous event) in each event was counted as an additional measure of difficulty. Where the number of new maneuvers was above zero for at least some members of each group, Quade's ANCOVA was conducted as well, using the number of new maneuvers as a covariate, ERS as the dependent variable, and group (legacy vs Avenger) as the independent variable. For some events, the number of new maneuvers was zero for all SNAs in one or both groups (i.e., no variability), preventing the use of new maneuvers as a covariate.

The research team also utilized the number of prior graded events (i.e., the number of graded events completed before the event being analyzed, including UTDs, OFTs, and live flights) as a covariate where feasible. A tenet of Project Avenger was to progress SNAs when they demonstrated proficiency, rather than keeping them in a portion of the syllabus until they completed a required block of events. As a result, they may have had less opportunity than legacy SNAs to receive high grades due to frequent, repeated practice of the same maneuvers across several events. Controlling for the number of prior graded events was a means of accounting for Project Avenger's push towards efficiency and its potential consequences for event grades. For analyses using the number of prior graded events, three different counts were employed in separate analyses where appropriate: flights only, SIMs (UTDs and OFTs) only, and flights + SIMs combined. Repeats and modified events (e.g., progress checkrides, warmup sorties, etc.) were included in the counts.

6.1.1. Overall Grades

There was complete, maneuver-level grade data for all Project Avenger SNAs. The overall Primary training ERS was calculated from the maneuvers in all events, using the same formulas for unweighted and difficulty-weighted grades that were used for calculating ERS in individual events:

$$unweighted\ grade = \frac{Sum\ of\ Maneuver\ Grades}{Sum\ of\ MIF}$$

$$weighted\ grade = \frac{Sum\ of\ Maneuver\ Grades + (Sum\ of\ Difficulty\ Levels/2)}{Sum\ of\ MIF}$$

ERS for legacy SNAs was calculated from the maneuver-level dataset using the same formula for unweighted grades. However, some events were missing for some SNAs. In those cases, an estimated ERS was still calculated using the same formula on all non-missing events and included in analysis(i.e., they were treated as complete records despite missing some event data).

Two Mann-Whitney *U* tests were conducted, one comparing Avenger's unweighted overall grades to legacy overall grades, and one comparing Avenger's difficulty-weighted overall grades to legacy overall grades. For both unweighted ERS and ERS weighted by Avenger's difficulty weightings, Avenger SNAs tended to receive a lower overall grade than legacy SNAs (Table 4). For Avenger SNAs, the mean score was 1.13 with a minimum overall unweighted ERS of 1.072, and a maximum of 1.173 (1.074 and 1.174 for weighted ERS). For legacy SNAs, the mean was 1.21 with a minimum overall ERS of 1.116 and a maximum of 1.353. Therefore, some Avenger SNAs performed better than some legacy SNAs, but the general trend was toward better performance for legacy SNAs.

In addition, the total number of graded events completed as well as split between flights and SIMs (i.e., three counts: flights, SIMs, and flights + SIMs) was counted for each SNA to examine whether it accounted for any of the variation in grades. Using these three different counts, three different Quade's ANCOVAs were conducted, with syllabus (Avenger vs legacy) as the independent variable, unweighted or weighted overall ERS as the dependent variable, and number of events as the covariate. Project Avenger SNAs still received a significantly lower overall ERS than legacy SNAs, regardless of difficulty weightings and regardless of number of graded events, number of flights, or number of simulators (Table 5). This means the number of graded events did not account for enough variance to change the statistically significant difference between Avenger and legacy overall grades.

Finally, the number of unique maneuvers attempted in M4000-level events (Mission Stage flights), whether or not they were new maneuvers, was employed as a proxy for SNAs' tendency to challenge themselves (i.e., a higher number of unique maneuvers attempted in the Mission Stage may indicate a greater challenge during the most complex and realistic Stage of the syllabus). "Unique maneuvers" is defined as all maneuvers completed in M4000-level events, where a maneuver that is repeated multiple times is counted only once. For example, if an SNA completed 90 maneuvers, but 5 were repeats of maneuvers they had already attempted in the events, then the SNA completed 85 unique maneuvers. Kendall's Tau-b was used to determine if there is a correlation between number of unique maneuvers attempted in the Mission Stage and overall ERS among Project Avenger SNAs. The relationship was significantly negative, $\tau_b = -3.70$, $p = 0.031$

for both unweighted and difficulty-weighted ERS. This shows that attempting unique maneuvers was associated with poorer grades. Furthermore, it indicates that Avenger's difficulty weightings did not counteract the trend of SNAs receiving lower grades simply for attempting unique maneuvers.

6.1.2. Pre-Mission Stage Grades

Final Simulator Event before Flights

For the final simulator event before live flight, the mean ERS of events C3101 and C3102 (legacy) was calculated so that both final simulator events contributed equally to the score being compared to Avenger's final simulator before flights. ERS for Q3101 (Avenger) was then compared to the mean of ERS for C3101 and C3102 (legacy). For both unweighted and difficulty-weighted ERS, legacy SNAs tended to score higher than Avenger SNAs. This indicates legacy SNAs are performing better on their final simulator event than Avenger SNAs. This pattern did not change when the research team conducted Quade's ANCOVAs and added the number of new maneuvers attempted (Table 4) or number of prior graded SIMs[1] (Table 5) as covariates for the SNAs who completed Avenger and the legacy SNAs with complete sets of maneuver and event data. This indicates the lower scores in Project Avenger could not be explained by differences in level of difficulty or level of experience. A Mann-Whitney *U* test indicated Avenger SNAs had, on average, about five more prior SIMs than legacy SNAs ($U = 5$, $p < .001$), but the Quade's ANCOVA shows this does not account for the statistically significant difference in scores.

First Flight

For the first live flight, event C4101 (legacy) was compared to Q4T01 (Avenger). As with the final pre-flight simulator events, legacy SNAs tended to score higher than Avenger SNAs for both unweighted and difficulty-weighted ERS. This pattern did not change when the research team added the number of new maneuvers attempted (Table 4) or number of prior graded SIMs[2] (Table 5) as

[1] Number of prior flights and number of prior flights + SIMs were not employed as covariates for this event, as the number of prior flights was zero for most SNAs.

[2] Number of prior flights and number of prior flights + SIMs were not employed as covariates for this event, as the number of prior flights was zero for most SNAs.

covariates, indicating that the lower Avenger score could not be attributed to differences in challenge or experience. A Mann-Whitney *U* test indicated that Avenger SNAs had about 2 more prior SIMs than legacy SNAs ($U = 3805.5$, $p < .001$), but as the covariate analysis showed, this did not account for the difference in scores (i.e., significant score difference remained).

Pre-Solo Flight

For the pre-solo flight, event C4304 (legacy) was compared to the last Q4T event completed before the solo. Q4T events ranged from Q4T01 to Q4T14, and the last Q4T event completed before solo ranged from Q4T07 to Q4Tll, meaning 7 to 11 Q4T events were completed before solo, not counting repeats ($M = 8.76$, $SD = 1.30$). With repeats, the number of Q4T events completed before solo ranged from 7 to 12 ($M = 9.24$, $SD = 1.48$). For the legacy syllabus, the pre-solo flight is roughly the 14th flight in the syllabus ($M = 14.34$, $SD = 2.32$).

The difference between Avenger and legacy scores on the pre-solo flight was not significant, with or without difficulty weightings on ERS, indicating roughly comparable ERS between the two syllabi (Table 4). New maneuvers were not evaluated as a covariate for this event due to legacy SNAs not attempting any new maneuvers on their pre-solo flight. For prior events, two Avenger SNAs had no initial solo flight recorded, bringing the Avenger sample size down to 17 for the covariate analyses using counts of prior events. All Quade's ANCOVAs were non-significant, indicating that ERS was roughly comparable between the two syllabi, even when accounting for the number of prior events (i.e., including the number of prior events did not change the pattern of performance). These Quade's ANCOVAs and numbers of prior events are displayed in Table 5.

Further investigation with Mann-Whitney *U* tests indicated that Avenger SNAs had, on average, approximately two fewer prior events ($U = 6743$, $p = .004$) equating to approximately four fewer flights ($U = 1457.5$, $p < .001$) than legacy SNAs, but an additional two SIMs ($U = 3920.5$, $p < .001$). This result is in line with CNATRA's analysis of the number of flights required to reach the Safe for Solo milestone, in which they found that Project Avenger SNAs required about five fewer flights than legacy SNAs to reach Safe for Solo. These results indicate that

Avenger SNAs achieve equivalent performance on their pre-Solo flight in fewer events than legacy, and this is not explained by differences in number of events.

First Cross-Country Flight

For the first cross-country flight, the mean ERS of events I4301 and I4302 (legacy) was compared to the mean ERS of events Q4N01 and Q4N02 (Avenger). Avenger SNAs tended to score higher than legacy SNAs, with or without difficulty weightings on ERS. Whereas Avenger SNAs attempted new maneuvers in their first cross-country flight, legacy SNAs attempted no new maneuvers (0 maneuvers for all SNAs), so Quade's ANCOVA was not conducted with number of new maneuvers attempted as a covariate (Table 4).

Quade's ANCOVAs were conducted on ERS and difficulty-weighted ERS, with the number of all prior graded events, flights, or SIMs as the covariate (Table 5). Covariate results for prior flights were significant and mirrored results that did not include covariates (i.e., Avenger SNAs performed better than legacy SNAs). By contrast, the two Quade's ANCOVAs using all prior events and prior SIMs only as a covariate were not significant. The mixed ANCOVA results suggest that prior SIM events may account for some of the difference in grades. However, Mann-Whitney *U* tests showed Project Avenger SNAs had far fewer events, flights, and SIMs ($U = 0$, $p < .001$ for all) prior to the first cross-country flight than legacy SNAs. The combination of these results indicates that Project Avenger SNAs received higher scores for the cross-country flight than legacy with less prior practice (i.e., fewer flights and SIMs), regardless of any interaction between number of events and differences in scores.

First Formation Flight

For the first Formation flight, ERS for event F4101 (legacy) was compared to ERS for event Q4F01 (Avenger). For both unweighted and difficulty-weighted ERS, Avenger SNAs tended to score higher than legacy SNAs. This pattern did not change when the research team added the number of new maneuvers attempted (Table 4) or number of prior graded events, prior flights, or prior SIMs (Table 5) as the covariate via Quade's ANCOVAs, indicating that Avenger's advantage was not attributable to the level of challenge or experience with which SNAs approached the event. Given that Mann-Whitney *U* tests also show Avenger SNAs had far

fewer prior events, flights, and SIMs than legacy SNAs (U < 6462, p < .003 for all), this indicates Avenger SNAs performed at a higher level with less practice and with more challenging events (i.e., more unique maneuvers attempted) than legacy on the first formation flight.

Fourth Formation Flight

For the Fourth Formation flight, ERS for event F4104 (legacy) was compared to ERS for event Q4F04 (Avenger). For both weighted and unweighted ERS, the Avenger group had a slight tendency to score higher than the legacy group, but the difference did not reach significance (p = .094 for unweighted ERS, p = .083 for difficulty-weighted ERS). The pattern did not change or reach significance when the research team added the number of new maneuvers attempted (Table 4) or the number of prior graded events, prior flights, or prior SIMs (Table 5) as the covariate for Quade's ANCOVAs. Mann-Whitney U tests indicated that Avenger SNAs had far fewer prior events, flights, and SIMs than legacy SNAs (U < 7453, p < .003 for all). These results indicate Avenger scores are greater than or equal to legacy for formation flights despite fewer prior events to practice and prepare

Table 4. Mann-Whitney *U* tests and Quade's ANCOVAs on pre-Mission Stage ERS with number of unique maneuvers

Event	Syllabus	*M*(*SD*) ERS	*M*(*SD*) ERS+dif	n_U	*U* ERS	*U* ERS+dif	*M*(*SD*) New Mnvrs	n_F	*F* ERS	*F* ERS+dif
Final SIM before flights (C3101+C3102; Q3101)	Legacy	**1.72** (0.12)	**1.72** (0.12)	3181	**3473⁺**	**3504⁺**	7.88 (0.79)	1338	**44.96⁺**	**44.86⁺**
	Avenger	**1.37** (0.16)	**1.38** (0.16)	19			1.70 (1.13)	19		
First flight (C4101; Q4T01)	Legacy	**1.22** (0.13)	**1.22** (0.13)	3180	**489⁺**	**489⁺**	2.65 (1.09)	1337	**92.89⁺**	**92.33⁺**
	Avenger	**0.91** (0.05)	**0.92** (0.06)	19			35.70 (3.61)	19		
Pre-solo flight (C4304; Q4TXX)	Legacy	1.11 (0.04)	1.11 (0.04)	3158	22,878	22,080	0 (0)	1320	N/A	N/A
	Avenger	1.12 (0.04)	1.12 (0.04)	17			1.29 (1.72)	17		
First CCX (I4301+I4302; Q4N01+Q4N02)	Legacy	**1.03** (0.03)	**1.03** (0.03)	3178	**301⁺**	**292⁺**	0 (0)	1338	N/A	N/A
	Avenger	**1.16** (0.05)	**1.16** (0.05)	19			3.05 (1.09)	19		
First formation flight (F4101; Q4F01)	Legacy	**1.05** (0.05)	**1.05** (0.05)	3178	**19,712****	**19,576****	3.31 (0.77)	1338	**7.02****	**7.20****
	Avenger	**1.09** (0.07)	**1.09** (0.07)	19			17.68 (2.12)	19		
Fourth formation flight (F4104; Q4F04)	Legacy	1.12 (0.05)	1.12 (0.05)	3178	23,479°	23,230°	0.03 (0.18)	1338	2.33	2.50
	Avenger	1.15 (0.08)	1.15 (0.08)	19			0.79 (0.98)	19		
Overall Grade	Legacy	**1.21** (0.04)	**1.21** (0.04)	1415	**912⁺**	**983⁺**	N/A	N/A	N/A	N/A
	Avenger	**1.13** (0.03)	**1.13** (0.03)	19			N/A	N/A		

Note. CCX = cross country flight, *M* and *SD* = mean and standard deviation, ERS+dif = difficulty-weighted Event Raw Score, n_U = number of participants in the Mann-Whitney *U* tests of ERS, *U* = Mann-Whitney *U* statistic, New Mnvrs = number of new maneuvers attempted in the event, n_F = number of participants in the Quade's ANCOVA on ERS with number of maneuvers as a covariate, *F* = Quade's *F* statistic. Significant *U* and *F* statistics are indicated with bold text. For the fourth formation flight, Quade's ANCOVA is included, but should be interpreted with caution, because the majority of legacy SNAs attempted 0 new maneuvers.* = $p < .05$, ** = $p < .001$, ⁺ = $p < .001$, ° = $p < .1$.

Table 5. Quade's ANCOVA on pre-Mission Stage ERS with number of prior events

Event	Syl.	*M*(*SD*) ERS	*M*(*SD*) ERS+ dif	*n*	*M*(*SD*) All Prior Events	*M*(*SD*) Prior Flights	*M*(*SD*) Prior SIMs	*F* All Prior Events (ERS)	*F* All Prior Events (ERS+ dif)	*F* Prior Flights (ERS)	*F* Prior Flights (ERS+ dif)	*F* Prior SIMs (ERS)	*F* *Prior SIMs (ERS+ dif)*
Final SIM before flights (C3101+ C3102; Q3101)	Legacy	**1.72** (0.12)	**1.72** (0.12)	1338	N/A	N/A	9.07 (0.33)	N/A	N/A	N/A	N/A	**29.32⁺**	**29.25⁺**
	Avenger	**1.37** (0.16)	**1.38** (0.16)	19	N/A	N/A	13.58 (0.77)						
First flight (C4101; Q4T01)	Legacy	**1.26** (0.13)	**1.26** (0.13)	1337	N/A	N/A	12.16 (1.76)	N/A	N/A	N/A	N/A	**56.44⁺**	**56.20⁺**
	Avenger	**0.91** (0.05	**0.92** (0.06)	19	N/A	N/A	14.21 (2.37)						
Pre-solo flight (C4304; Q4TXX)	Legacy	1.11 (0.04)	1.11 (0.04)	1320	29.63 (3.10)	13.34 (2.32)	16.28 (1.75)	0.13	0.11	0.62	0.32	0.23	0.49
	Avenger	1.12 (0.04)	1.12 (0.04)	17	27.59 (4.71)	9.12 (3.57)	18.47 (1.81)						
First CCX (I4301+ I4302; Q4N01+ Q4N02)	Legacy	**1.03** (0.03)	**1.03** (0.03)	1339	73.86 (5.67)	36.83 (4.84)	37.03 (1.98)	0.01	0.09	**40.84⁺**	**40.86⁺**	0.46	0.79
	Avenger	**1.16** (0.05)	**1.16** (0.05)	19	34.79 (3.78)	12.58 (3.52)	22.21 (1.13)						

Event	Syl.	*M*(*SD*) ERS	*M*(*SD*) ERS+ dif	*n*	*M*(*SD*) All Prior Events	*M*(*SD*) Prior Flights	*M*(*SD*) Prior SIMs	*F* All Prior Events (ERS)	*F* All Prior Events (ERS+ dif)	*F* Prior Flights (ERS)	*F* Prior Flights (ERS+ dif)	*F* Prior SIMs (ERS)	*F* *Prior SIMs (ERS+ dif)*
First FRM flight (F4101; Q4F01)	Legacy	**1.05** (0.04)	**1.05** (0.04)	1338	68.74 (17.48)	36.68 (8.89)	32.05 (8.93)	**6.41***	**6.56***	**6.21***	**6.35***	**7.14****	**7.30****
	Avenger	**1.09** (0.07)	**1.09** (0.07)	19	37.11 (4.14)	14.89 (3.77)	22.21 (1.13)						
Fourth FRM flight (F4104; Q4F04)	Legacy	1.12 (0.05)	1.12 (0.05)	1338	71.94 (17.47)	39.88 (8.89)	32.06 (8.92)	2.40	2.57	1.98	2.14	3.28°	3.49°
	Avenger	1.15 (0.08)	1.15 (0.08)	19	39.89 (4.57)	17.68 (4.12)	22.21 (1.13)						
Overall grade[§]	Legacy	**1.21** (0.04)	**1.21** (0.04)	1412	87.31 (4.39)	49.47 (3.48)	37.84(1.97)	**70.48^{+}**	**69.80^{+}**	**69.55^{+}**	**68.86^{+}**	**51.71^{+}**	**51.14^{+}**
	Avenger	**1.13** (0.03)	**1.13** (0.03)	19	71.42 (4.39)	43.05 (3.70)	28.37 (1.34)						

Note. Syl. = Syllabus, CCX = Cross-Country Flight, FRM = Formation, *M* = Mean, *SD* = Standard Deviation, ERS+dif = difficulty-weighted Event Raw Score, *n* = number of SNAs, *F* = Quade's ANCOVA statistic. "All Prior Events" includes prior flights + prior SIMs. Prior SIMs include UTD events and OFT events. * = $p < .05$, ** = $p < .01$, $^{+}$ = $p < .001$, $^{\circ}$ = $p < .1$. [§]For the overall grade, "prior events" refers to all graded flights and SIMs completed during Primary training.

6.1.3. Mission Stage Grades

Mission Stage 4000-Level Flights

As with Q4T events, the number of M4000 events completed depends on IPs' judgment of each SNA's proficiency to advance to the Mission Stage solo flight. The location of the solo flight in the Mission Stage also varied, based on both IP judgments of readiness and scheduling efficiencies, such that some SNAs continued to fly M4000-level events after the solo flight. The number of M4000 events completed by SNAs ranged from 7 to 13 (M4007 to M4013; M = 8.95, SD = 1.54). For this section, all M4000 flights that each SNA completed were included in analysis, including the ones that occurred after the solo flight.

As described above in Section 5.3, "Procedures," the research team isolated maneuvers that occurred in M4000-level flights in Avenger and in advanced flights from each block of the legacy syllabus. These maneuvers from the multiple events were then combined into a single artificial event. ERS for this artificial event was calculated using the same formula used for real events. In the maneuver-level dataset, some events were missing for two SNAs who completed Primary training; these SNAs were excluded from analysis. The events from which maneuvers were taken are listed above in Table 3 and in the results table (Table 6).

Two different sets of maneuvers were used to create the artificial event and its ERS, in order to conduct two sets of analyses. The purpose of utilizing these two different sets was twofold: to evaluate a measure of comparable grades; and also evaluate grades that included Avenger-specific maneuvers, such as "Inflight Adaptability," that may have captured Avenger's focus on creating a generalized aviator better than maneuvers with legacy equivalents.

In one maneuver set, any maneuver that was completed at least once by at least 15 Avenger SNAs, and also occurred (or had a close equivalent) in the legacy syllabus events, was included in the list ("equivalent maneuvers"). Some of Avenger's maneuvers are more specific than their legacy equivalent; for example, "Lead Change (Lead to Wing)" and "Lead Change (Wing to Lead)" were listed as equivalent to "Lead Change" from the legacy syllabus. This resulted in 48 possible maneuvers (Avenger) and 44 possible maneuvers (legacy) being included in the ERS

calculation for equivalent maneuvers. For individual SNAs, this translated to an average of 44.63 (*SD* = 5.23) maneuvers used for Avenger SNAs and 31.61 (*SD* = 6.83) maneuvers used for legacy SNAs. When Avenger maneuvers were renamed to match legacy maneuvers, resulting in 44 possible maneuvers for Avenger SNAs, individual SNAs completed an average of 40.79 (*SD* = 5.29) unique maneuvers. Mann-Whitney *U* tests indicated that Avenger SNAs had a significantly higher number of equivalent maneuvers than legacy SNAs, using both the original maneuver count and the count of renamed maneuvers ($U < 2497$, $p < .001$ for both).

In the second maneuver set, all maneuvers from M4000 events and all maneuvers from the legacy events were included, whether or not they occurred in common between the two syllabi ("all maneuvers"). For Avenger SNAs, this included 116 different possible maneuvers; for legacy SNAs, it included 79 different possible maneuvers. For individual SNAs, Avenger had an average of 92.37 (*SD* = 4.21) original maneuvers and 88.53 (*SD* = 3.95) renamed maneuvers, and legacy had an average of 53.74 (*SD* = 8.86) maneuvers. Again, Avenger SNAs completed significantly more unique maneuvers than the legacy SNAs, counting both original and renamed maneuvers ($U = 0$, $p < .001$ for both).

Since individual maneuvers were taken from multiple events to create an artificial ERS, difficulty weightings were not included in Mission Stage analyses. Analyses throughout this section are limited to unweighted ERS as the dependent variable. For equivalent maneuvers, ERS among legacy SNAs was higher than Avenger SNAs. This pattern was not changed by using all maneuvers for analysis (Table 6). Therefore, regardless of maneuver set, legacy SNAs tended to receive better grades than Avenger SNAs on end-of-block flights compared to Avenger Mission Stage flights.

Additionally, covariates were examined to determine if they had any effects. The number of new maneuvers attempted was 0 for all legacy SNAs, so it was not used as a covariate. Because the number of prior events is not comparable between Avenger and legacy due to legacy comparison events occurring at different points during the syllabus, total numbers of syllabus events were used as covariates instead of prior events. Specifically, the overall numbers of flights, graded SIMs, and flights + SIMs completed during Primary training were used as covariates in six separate Quade's ANCOVAs: flights, SIMs, and flights + SIMs as

covariates for equivalent maneuvers; and flights, SIMs, and flights + SIMs as covariates for all maneuvers. In all six cases, the results were the same as without a covariate, such that legacy SNAs had a higher ERS than Avenger SNAs (Table 7). Thus, different numbers of events did not explain Avenger's lower M4000 ERS.

Table 6. Mann-Whitney *U* tests on Mission Stage artificial ERS

Events	Syllabus	Events Included	*M*(*SD*) ERS	*n*	*U*
Advanced flights/ Mission Stage equivalent maneuvers	Legacy	C4603, C4604, I4304, I4305, N4201, N4202, F4301, F4302	**1.04** (0.02)	1413	**5558⁺**
	Avenger	All M4000-level events	**1.02** (0.02)	19	
Advanced flights/ Mission Stage all maneuvers	Legacy	C4603, C4604, I4304, I4305, N4201, N4202, F4301, F4302	**1.06** (0.02)	1413	**1227⁺**
	Avenger	All M4000-level events	**1.02** (0.02)	19	
Checkrides equivalent maneuvers	Legacy	C4490, C4790, I4490	**1.06** (0.02)	1413	**8520****
	Avenger	M4190A, M4190B	**1.05** (0.03)	19	
Checkrides all maneuvers	Legacy	C4490, C4790, I4490	**1.07** (0.02)	1413	**4608⁺**
	Avenger	M4190A, M4190B	**1.03** (0.03)	19	

Note. *M* and *SD* = mean and standard deviation, *n* = number of participants in the Mann-Whitney *U* tests of ERS, *U* = Mann-Whitney *U* statistic, * = $p < .05$, ** = $p < .001$, ⁺ = $p < .001$, ° = $p < .1$.

Table 7. Quade's ANCOVA on Mission Stage ERS with number of prior events or unique maneuvers

Events	Syllabus	Events Included	*M*(*SD*) ERS	*n*	*M*(SD) All Graded Events	*M*(SD) Flights	*M*(SD) SIMs	*M*(SD) Unique Mnvrs	*F* All Graded Events	*F* Flights	*F* SIMs	*F* Unique Mnvrs
Advanced flights/ Mission Stage equivalent maneuvers	Legacy	C4603, C4604, I4304, I4305, N4201, N4202, F4301, F4302	**1.04** (0.02)	1412	87.31 (4.39)	49.47 (3.48)	37.84 (1.97)	N/A	**25.37⁺**	**24.65⁺**	**20.36⁺**	N/A
	Avenger	All M4000-level events	**1.02** (0.02)	19	71.42 (4.39)	43.05 (3.70)	28.37 (1.34)	N/A				
Advanced flights/ Mission Stage all maneuvers	Legacy	C4603, C4604, I4304, I4305, N4201, N4202, F4301, F4302	**1.06** (0.02)	1412	87.31 (4.39)	49.47 (3.48)	37.84 (1.97)	N/A	**66.48⁺**	**64.02⁺**	**51.70⁺**	N/A
	Avenger	All M4000-level events	**1.02** (0.02)	19	71.42 (4.39)	43.05 (3.70)	28.37 (1.34)	N/A				
Checkrides equivalent maneuvers	Legacy	C4490, C4790, I4490	**1.06** (0.02)	1413	N/A	N/A	N/A	43.93 (2.56)	N/A	N/A	N/A	**5.15***
	Avenger	M4190A, M4190B	**1.05** (0.03)	19	N/A	N/A	N/A	70.21 (5.88)				
Checkrides all maneuvers	Legacy	C4490, C4790, I4490	**1.07** (0.02)	1413	N/A	N/A	N/A	43.93 (2.56)	N/A	N/A	N/A	**19.63⁺**
	Avenger	M4190A, M4190B	**1.03** (0.03)	19	N/A	N/A	N/A	70.21 (5.88)				

Note. *M* and *SD* = mean and standard deviation *n* = number of participants in the Quade's ANCOVAs, *F* = Quade's ANCOVA statistic, Mnvrs = Maneuvers. "All Prior Events" includes prior flights + prior SIMs. Prior SIMs include UTD events and OFT events. * = $p < .05$, ** = $p < .001$, ⁺ = $p < .001$, ° = $p < .1$.

Mission Stage Checkrides

Avenger's Mission Stage checkrides (events M4190A and B) have no direct equivalent in the legacy syllabus. The legacy syllabus checkrides (Contact and Instruments) were determined to be the closest equivalent as a comparison of performance in the flights in which SNAs should be at their best performance, and were used for the analyses in this section. However, legacy checkrides occur earlier in training and within the block of skills they are intended to test. Avenger's checkrides, by contrast, occur at the end of the syllabus and, as with the Mission Phase in general, are intended to put together multiple and diverse sets of skills from across all stages previously learned in Primary training. For this reason, the results in this section should be interpreted with caution.

For these analyses, maneuvers were isolated in the same way as described for M4000-level flights, including equivalent maneuvers (attempted by at least 15 Avenger SNAs and also occurring or having a close equivalent in the comparison events of the legacy syllabus) and all maneuvers (all maneuvers occurring in M4190A and B for Avenger SNAs and all maneuvers occurring in the comparison checkrides for legacy SNAs). For the equivalent maneuvers, this resulted in 26 possible maneuvers from both Avenger and legacy checkrides, with individual Avenger SNAs completing an average of 23.16 (SD = 4.32) maneuvers and legacy SNAs completing 24.83 (SD = 0.67) maneuvers. For all maneuvers, there were 99 possible maneuvers from the Avenger syllabus and 63 possible maneuvers from the legacy syllabus, with Avenger SNAs completing an average of 70.21 (SD = 5.88) and legacy SNAs completing an average of 43.93 (SD = 2.56). Mann-Whitney U tests indicated no significant difference between Avenger and legacy SNAs on the number of equivalent maneuvers completed (U = 12,192.5, p = .431), but Avenger SNAs completed significantly more checkride maneuvers when looking at the list of all maneuvers (U = 0, $p < .001$), suggesting that Avenger's checkrides were more complex than the legacy checkrides and covered a broader set of skills.

Legacy SNAs received higher scores than Avenger SNAs on both the set of equivalent maneuvers and the set of all maneuvers (Table 6). As with M4000 events, the checkride ERS was created from individual maneuvers taken from multiple events, so difficulty weighting were not employed; all analyses in this section use

unweighted ERS as the dependent variable. The number of new maneuvers attempted in checkrides was 0 for all legacy SNAs, so it was not used as a covariate. However, the number of unique maneuvers completed in the events serves as an alternate measure of difficulty, as more maneuvers completed may indicate a more complex event. Therefore, the number of unique maneuvers completed in the checkrides was employed as a covariate and two Quade's ANCOVAs were conducted, one using ERS based on equivalent maneuvers and one using ERS based on all maneuvers as the dependent variable. Both cases were statistically significant and show that legacy SNAs still performed better than Avenger SNAs (Table 7), indicating that event complexity did not account for enough variance in Avenger's lower scores to remove the significant difference.

6.1.4. Summary of Grade Results

Referring back to the introduction's description of Project Avenger, grade results were in line with expectations based on Avenger's design: for general comparisons, legacy SNAs tended to receive higher grades than Project Avenger SNAs; but, in some instances, it was reversed such that Avenger SNAs received higher grades. For overall performance (ERS), the legacy average was higher than Project Avenger but closer examination revealed that Avenger SNAs received higher grades than legacy or achieved similar grades with fewer prior events (i.e., less practice) on specific events in the Qualification Stage. When looking at Avenger's lower grades in the Mission Stage, examination of the maneuver-level data showed Avenger SNAs completing more unique maneuvers than their legacy peers, indicating difficulty weightings were likely insufficient to compensate for more challenging events (i.e., more unique maneuvers attempted). This may have partially contributed to Avenger's lower overall ERS.

The mixed results on individual events or groups of events should be interpreted with an understanding of the different instructional and learning designs of the syllabi. In the Qualification Stage, Avenger SNAs received lower grades than legacy SNAs early on, but caught up to, and in some cases surpassed, the legacy SNAs even with fewer prior events. Avenger SNAs therefore presented a steeper learning curve than legacy SNAs (i.e., the Avenger SNAs reached certain skill levels faster than legacy). Lastly, the research team created two artificial events from multiple Mission Stage (Avenger) or "Mission-Stage-

equivalent" (legacy) events to account for no comparable equivalents across the syllabi. In Mission Stage analyses, legacy SNAs again outperformed Avenger SNAs. However, due to syllabus differences, the results from the Mission Stage should be interpreted with caution: the Mission Stage is an entirely new style of training event and the artificial events created for the analyses may not have been similar enough between the two syllabi to conduct an accurate comparison.

6.2. Efficiency

6.2.1. Time to Train

The number of days to complete training was compared between the Avenger and legacy syllabus. For the legacy syllabus, this was defined as the number of days between the first and last event recorded in the TIMS data. For both Avenger and legacy, this was defined as the number of days between each syllabus's first UTD event, B1001 for Avenger and C2101 for legacy, and the last event recorded in the gradebook[3]. It is important to note that SNAs did not complete events the same order and therefore did not all have the same final event; the research team defined the "last event" as the last one chronologically recorded in the gradebook (Avenger) or TIMS (legacy).

In addition, two different groups of legacy SNAs were used for comparison to Avenger SNAs. In the TIMS data received, some SNAs who began their graded events in May 2019 or later had events N4102, N4202, F4301, and F4302 waived; and all SNAs who began graded events after November 2019 had these four flights waived. As a result, the number of flights differed for legacy SNAs depending on when they started training, which would affect their total time to train. Therefore, legacy SNAs were divided into those who had the four flights waived ("waived legacy") and those who did not ("traditional legacy") for counts that included flights.

Two Mann-Whitney *U* tests were conducted to compare Avenger SNAs to waived legacy SNAs and traditional legacy SNAs. In both cases, Avenger SNAs required significantly less time to complete

[3] The Avenger gradebooks included an event, Q6001, that was completed prior to B1001, but Q6001 was the orientation to the ITDs. It was not intended to teach pilot skills, and no similar event existed in the TIMS dataset. B1001, a UTD event, was more similar to the SIM events with which legacy SNAs' TIMS data began.

training than legacy SNAs, by nearly a month compared to the "Waived Legacy" syllabus and nearly two months compared to the "traditional" (Table 8). This accords with CNATRA's own analysis of time to train, which indicated Project Avenger required 8.5% less time than the legacy syllabus.

Table 8. Mann-Whitney *U* tests of number of days in training

Syllabus	*M (Months)*	*SD*	*n*	*U*	*p*
Traditional Legacy	**7.34**	1.82	819	**4019**	<.001
Waived Legacy	**6.57**	1.23	593	**2848.5**	<.001
Avenger	**5.69**	0.26	19		

Note. Waived Legacy = legacy syllabus with four flights waived, Traditional Legacy = legacy syllabus without flights waived, *M* = mean number of months to complete training (where 1 month = 30 days), *SD* = standard deviation of number of months, *n* = number of participants, *U* = Mann-Whitney *U* statistic, and *p* = two-tailed significance. Significant Mann-Whitney *U* values are indicated with bold text.

6.2.2. Numbers of Events

Syllabus Events

In this section, "count of events" is defined as the number of flight and SIM events completed as part of the syllabus, including extra events such as reflys and warmup sorties. Analyses focused on graded events for SNAs with complete maneuver data, categorized into different types: number of flights, number of UTD events, number of OFT events, total number of SIM events (UTD and OFT events combined), and total number of graded events (flights, UTDs, and OFTs). Additionally, descriptive data are provided for two different sets of ITD events: regular ITD events and Post-Req ITD events. "Regular ITD events" includes events that are a regular part of the syllabus for all SNAs. "Post-Req ITD events" are homework events: additional practice assigned to individual SNAs to be completed on their own. Finally, the total number of regular syllabus events were counted, which included regular ITDs, UTDs, OFTs, and flights, but excluded post-req ITDs.[4] See Table 9 for numbers of events completed.

[4] For the legacy syllabus, the total number of graded events and the total number of graded and ungraded events are the same, because legacy training does not include ITDs.

Due to the waiving of four flights for some legacy SNAs, event counts that included flights were compared using two different legacy totals. Different Mann-Whitney *U* tests were conducted to compare Avenger to waived legacy SNAs and to compare Avenger to traditional legacy SNAs. Not surprisingly, given Avenger included a large number of ITD events, Avenger SNAs had a higher total number of syllabus events when regular ITDs were included (waived $U = 0$, $p < .001$; traditional $U = 23$, $p < .001$). However, Avenger SNAs had a lower number of graded events (waived $U = 99.5$, $p < .001$; traditional $U = 0$, $p < .001$) and a lower number of flights (waived $U = 2163$, $p < .001$, traditional $U = 000$, $p < .001$), indicating its integration of VR events allows for greater efficiency when compared to the legacy syllabus.

Table 9. Counts of syllabus events and extra events

Event Category	*Syllabus*	*M*	*SD*	Min	Max	*n*
Regular ITDs	Legacy	0	0	0	0	N/A
	Avenger	34.11	1.15	31	35	19
Post-Req ITDs	Legacy	0	0	0	0	N/A
	Avenger	2.16	6.64	0	29	19
UTDs + OFTs	Legacy	**37.84**	1.97	36	48	1412
	Avenger	**28.37**	1.34	27	32	19
UTDs	Legacy	**12.14**	0.48	12	18	1412
	Avenger	**17.00**	1.00	16	19	19
OFTs	Legacy	**25.71**	1.89	24	36	1412
	Avenger	**11.37**	1.01	10	14	19
Flights	Waived	**47.15**	2.89	43	63	593
	Traditional	**51.15**	2.86	47	66	819
	Avenger	**43.05**	3.70	39	51	19
All graded events	Waived	**84.52**	3.51	79	99	593
	Traditional	**89.34**	3.82	83	103	819
	Avenger	**71.42**	4.39	66	81	19
All regular events	Waived	**84.52**	3.51	79	99	593
	Traditional	**89.34**	3.82	83	103	819
	Avenger	**105.53**	4.18	101	116	19
All extra events	Legacy	3.71	3.35	0	19	1412
	Avenger	4.47	2.14	1	9	19
Reflys	Legacy	0.46	1.01	0	8	1412
	Avenger	2.89	1.76	0	6	19
Warmup sorties	Legacy	3.01	2.81	0	18	1412
	Avenger	1.53	0.77	1	3	19

Note. For each event category, Avenger and legacy means with statistically significant differences are indicated with bold text.

UTD events, OFT events, and total number of SIM events (UTD + OFT) were compared between Avenger and the entire group of legacy SNAs using Mann-Whitney *U* tests. Avenger had more UTD events ($U = 62.5$, $p < .001$), fewer OFT events ($U = 0$, $p < .001$), and fewer SIM events overall ($U = 0$, $p < .001$) compared to legacy. Thus, in spite of a relatively high number of UTD events, Avenger was more efficient than legacy in terms of the number of SIM events.

Extra Events

Extra events in the first class of Project Avenger were limited to reflys and warmup sorties; although there were some events coded 88, signifying a progress checkride, discussion with SMEs led the research team to classify these events as reflys. Therefore, Avenger reflys and warmup sorties, and all legacy extra events (reflys; adaptation, practice, warmup, and supplemental sorties; progress and elimination checkrides; extra training; and warmup events other than warmup sorties) were counted. Please note, due to the infrequency and low number of extra events, no significance testing was conducted. However, descriptive results show similar total numbers but differences in type: Avenger had more reflys on average (2.89 vs. 0.46) and legacy had more warmups (1.53 vs. 3.01; Table 9). Fewer warmups in Avenger indicates it is meeting its objective to provide a more flexible, efficient syllabus, because warmup sorties are utilized in legacy training when scheduling limitations or other obstacles have prevented an SNA from flying for up to two weeks.

6.2.3. Summary of Efficiency Analyses

In line with CNATRA's own analyses, the results here show Avenger required a shorter time to train than the legacy syllabus, even when four flights were removed from legacy training. Avenger had a higher overall number of required events, although that number includes ITD events (formal VR training not available to legacy trainees). However, Avenger had both fewer flights and fewer SIM events (UTDs and OFTs) than legacy training, indicating it is more efficient than legacy training in terms of costlier training events. Finally, though Avenger and the legacy syllabus do not differ appreciably on total extra events, they do differ in the sub-types of extra events. Thus, Project Avenger overall appears to be a more efficient training method than legacy training.

Grade analyses also indicate greater efficiency for Project Avenger. Both the number of flights and the overall number of graded events prior to solo, cross-country, and formation flights were lower in Project Avenger than in the legacy syllabus, even though Avenger SNAs had similar or higher grades on these events. This aligns with CNATRA's own analysis of flights required to reach the Safe for Solo milestone.

6.3. SNA Feedback

Results in this section are based on responses to the Student Feedback Questionnaire included by CNATRA in the Avenger syllabus, including median and interquartile range for Likert-type questions and categorized responses to free-response questions (Appendix 4). Responses are summarized separately for each sub-section of the questionnaire across the three syllabus Stages. It is important to note there were different response rates for each Stage: seventeen respondents for the Pre-Flight Stage, six respondents for the Qualification Stage, and fourteen respondents for the Mission Stage. Also, this section is solely a summary of SNA feedback; any recommendations from the research team derived from this information are provided in later sections.

In CNATRA's Student Feedback Questionnaire, ITDs were referred to as "VR Trainers" and MR UTDs were referred to as "Augmented Reality (UTD with VR headset)". The research team considers UTDs with headsets to be MR rather than Augmented Reality or VR, due to its combination of real-world and virtual responsive elements in a coherent display (see Milgram et al., 1994 for a definition of MR). However, the "VR Trainer" and "Augmented Reality" terminology is preserved in this section for two reasons. First, to maintain a clear relationship between this section, the questionnaire in Appendix 2, and the summary tables in Appendix 4; and second, because SNAs may have taken other XR devices into consideration when responding to "VR Trainer" questions. SNAs in class 1 of Project Avenger did not have an opportunity to use the Augmented Reality UTDs due to delays in acquisition. In spite of this, some SNAs responded to the Augmented Reality UTD questions; their responses are included below, as they may have been responding with their actual UTD events in mind, which did include monitors providing straight-ahead visuals.

All Likert-type responses are rated on scale of 1-6, with 1 being highly negative and 6 being highly positive. Response categories on the free-response questions are counted by each statement, not by respondent. For example, if one respondent stated that VR trainers are beneficial for learning Course Rules and communications, then "beneficial for Course Rules" was counted as one response and "beneficial for communications" was counted as one response.

6.3.1. Course Materials

This section will discuss students' opinions about the different attributes associated with the course materials used in Project Avenger. Each attribute is listed in its own subsection below, and feedback is presented across Stages within each subsection. Please refer to Appendix 4 for the full tables of results.

Accessibility

Overall, SNAs viewed accessibility to the course materials favorably in the Pre-Flight Stage, rating all items as a 6 ("always accessible") except for the VR trainers with instructor: rated a 3 ("somewhat accessible"). SNAs followed the same pattern for the Qualification Stage, except for 360-degree videos via YouTube and VR trainer with PilotEdge, which received slightly lower ratings of 5 (between "somewhat inaccessible" and "always accessible"), but rated VR trainers with instructor slightly higher at a 3.5. In the Mission Stage, SNAs responded more positively than the Qualification Stage for VR trainers with instructor, rating of 4.5 ("somewhat inaccessible") and 360-degree videos via YouTube with a rating of 5.5.

Frequency of Use

For frequency of use, technical manuals, ForeFlight, iPad, Google Drive ratings were a 6 ("all the time"), but Master Curriculum Guide (MCG) was rated a 3 ("sometimes but not often") across Stages. SNAs rated 360 videos with Oculus or via YouTube, and CloudAhoy a 3 in Pre-Flight. Reported frequency of use decreased in Qualification Stage for Avenger modules, VR trainer with PilotEdge, VR trainer with instructor, and 360 videos with Oculus the lowest at 2.5 ("sometimes but not often"). However, detachment IP and stash support remained high at 6. As training progressed in the Mission Stage, VR trainer with instructor and detachment IP and stash support were rated lower than previous

Stages and CloudAhoy, VR Training Solo Practice, and 360-degree Videos via YouTube were rated higher.

Ease of Use

Across Stages, ease of use was rated at a 6 ("extremely easy") for ForeFlight, iPads, and Google Drive. In addition, technical manuals and detachment IP and stash support were rated a 6 for Pre-flight and Mission, but slightly lower for the Qualification Stage with ratings of 5.5. Use of 360 videos with Oculus and YouTube were rated a 6 in Pre-Flight and were lowered to ratings of 4.5 and 4 ("somewhat easy") as the SNAs progressed through the Stages. The opposite was true for VR trainer with PilotEdge and VR training solo practice, such that ratings started lower in Pre-Flight (4 and 5 respectively) and were higher in the Qualification Stage, then remained the same in the Mission Stage. The use of MCG was rated a 3 ("somewhat difficult") for the first two Stages, but scored a 4 in the Mission Stage. In reverse, the Avenger modules had a rating of 5.5 for the first two Stages, but decreased to a 5 in the Mission Stage.

Beneficial to Learning

SNAs rated most of the course material as beneficial to learning, with scores of 5.5 or higher ("extremely beneficial") except for Avenger modules (ratings of 5, 4, 5 respectively), 360 videos with Oculus and via YouTube (4, 3.5, 4) and CloudAhoy (4, 3.5, 5). Although the MCG received the lowest ratings in this section, scores increased throughout training, going from a 3 ("some use but not much") in Pre-Flight, to 3.5 in Qualification, and a 4 ("somewhat beneficial") in the Mission Stage.

Relevant to Learning

Course materials' relevance to training remained consistent throughout training; VR trainer with PilotEdge, VR trainer with instructor, VR training solo practice, ForeFlight, iPads, Google Drive, and detachment IP and stash support received ratings of 6 ("extremely relevant") and 360 videos with Oculus and via YouTube received ratings of 4 ("somewhat relevant"). CloudAhoy ratings remained the same for Pre-Flight and Qualification Stage at a 4, but lowered slightly to a 3 in the Mission Stage. In addition, the MCG increased in rating across the three Stages (3, 3.5, and 4). Finally, SNAs' ratings of technical manuals and

Avenger modules were lower in Qualification than the Mission Stage.

Quality of Content

SNA's responses to quality of content remained at a 6 ("extremely high quality") for VR trainer with instructor, ForeFlight, iPad, and Google Drive across the Stages. On the one hand, some SNAs' ratings for quality were the same for Pre-Flight and Mission Stage but either were rated lower in the Qualification Stage (i.e., detachment IP and stash support, 360 videos with Oculus and via YouTube) or rated higher (i.e., MCG and VR training solo practice). On the other hand, technical manuals and VR trainer with PilotEdge scored a 6 in Pre-Flight and Qualification, but were rated slightly lower in the Mission Stage, receiving ratings of 5 and 5.5 respectively. Finally, the quality of Avenger modules and CloudAhoy shared similar trends, in which SNAs rated them a 4 ("somewhat high quality") in Pre-Flight, ratings were higher in the Qualification Stage (5.5 and 6), and decreased to a 5 in the Mission Stage.

Most/Least Beneficial

In the free-response questions, respondents across Stages frequently stated VR trainers and general iPad usage were the most beneficial. Specifically, VR trainers were best for learning course rules, communication, maneuvers, and sight picture for Flight Training Instruction (FTI) in the Pre-Flight Stage, skill practice in Qualification Stage, and flight planning in the Mission Stage. Overall, iPad usage was helpful for accessing content and flight planning throughout the Stages. On the other hand, the MCG was least beneficial across the Stages because it was difficult to navigate therefore unused. The 360-degree videos with Oculus and CloudAhoy were deemed less beneficial because other course materials were deemed more useful.

Improvement Recommendations

The most common types of recommendations for improving course materials across the three Stages included changes to the MCG, improvements to VR trainers, and changes to the training timeline. Regarding the MCG, SNAs recommended clarifying the syllabus flow, listing prerequisites for each event, showing relationship of course materials to each event, listing study

materials to review, and making it consistent with the gradebook. Regarding VR trainers, SNAs recommended replacing the HOTAS with a stick that provides force feedback, making the VR trainers more reliable, and adding a Flight Management System (FMS) capability. Regarding the training timeline, SNAs requested an increase in classroom instruction, placing VR trainer events before traditional SIM events, replacing the review of all flight systems into single-system reviews across different days, and more VR training with instructors in preparation for the Mission Stage. Suggested improvements also included making Google Drive easier to navigate, creating an iPad-friendly syllabus that indicates progress, and developing more 360 videos targeting more advanced flights and skillsets for later in the syllabus.

Summary of Course Materials Feedback

Course materials generally received high ratings, regardless of type or SNA's stage of training, indicating Project Avenger did well providing tools and materials to facilitate learning. More specifically, accessibility and quality of content ratings for course material were high across all three stages, except for the accessibility of VR trainers with instructor, which improved throughout training. Frequency of use was also similar across stages for all materials, but ratings were relatively lower for MCG, 360-degree videos with Oculus/YouTube, and CloudAhoy. Although MCG ratings were higher as SNAs progressed through the stages for ease of use, benefits to learning, and relevance to training, it was still deemed least beneficial based on SNA feedback. These ratings that started low and improved over time may be indicative of SNAs gaining more experience on how to navigate the MCG more effectively. However, in response to the comments, restructuring certain parts of the MCG could address the remaining concerns. Similarly, 360-degree videos with Oculus/YouTube may have received lower ratings because many videos were still under development at the commencement of Avenger. It is expected that their use and benefit to training will increase as more videos become available. Finally, CloudAhoy had lower ratings for both benefits to learning in the Qualification Stage and relevance to training in the Mission Stage. SNAs stated that the user interface was cluttered, but additional exploration is needed to identify the root cause. In summary, course materials used in Avenger were beneficial for

progressing through some if not all portions of the syllabus effectively.

6.3.2. Content and Delivery Method

This section will discuss student feedback on the quality of various delivery methods used to facilitate training in Project Avenger. Each attribute is listed in its own subsection below, and feedback is presented across Stages within each subsection. Please refer to Appendix 4 for the full tables of results.

Effectiveness of Delivery Method

The effectiveness of delivery methods in this section received positive responses of 4 ("somewhat effective") or higher in all methods across Stages; except for Avenger modules, which received a 3.5, and an N/A provided for both Augmented Reality (UTD with VR headset) and Mission flight events in the Qualification Stage. VR events with IP and PilotEdge's ratings remained at a 6 ("extremely effective") while at-home coursework ratings remained at a 4 throughout training. On the contrary, SNAs rated Avenger modules, in-person lectures, detachment IP and stash support, and Qualification flight events lower in the Qualification Stage than the other Stages. It is important to note respondents could have rated the UTD, IFT, Augmented Reality (MR UTD), Qualification flight events, and Mission flight events in the Pre-Flight Stage, but may not have had enough experience to make an informed rating. Some SNAs chose to rate them and some chose not to respond or to select the "N/A" response.

Engagement with the Material

On responses associated with content engagement, SNAs rated detachment IP and stash support, solo VR and simulator practice, VR events with IP, PilotEdge, and OFT at a 6 across the Stages and rated Avenger modules a 4 throughout training. Augmented Reality (UTD with VR headset) and mission flight events received a 4 ("somewhat engaged") rating during Pre-Flight, N/A for Qualification, and a 6 ("extremely engaged") for the Mission Stage. Both IFT and qualification flight events received scores of 5 for Pre-Flight and 6 for Qualification and Mission Stage.

Quality of Methodology

Responses for the quality of delivery methodology used also received consistent ratings across the three Stages for detachment IP and stash support, VR events with IP, and OFT receiving ratings of 6 ("extremely high quality"). Additionally, SNAs responded with a 4 ("somewhat high quality") across Stages for at-home coursework and Avenger modules. In-person lectures, PilotEdge, and UTD ratings were lower in the Qualification Stage than the other Stages, while solo VR and simulator practice and IFT were rated lower in the Mission Stage than in other Stages.

Understanding of the Material

Overall ratings of material understanding delivered in these methods were at a 4 ("somewhat understandable") or higher for all material across Stages. Specifically, solo VR and simulator practice, VR events with IP, PilotEdge, and qualification flight events scores remained the same across Stages. Augmented Reality (UTD with VR headset) and mission flight events received a 5 – 5.5("somewhat engaged") rating during Pre-Flight and Mission Stage, but N/A for Qualification Stage. Additionally, Qualification ratings for Avenger modules, in-person lectures, and detachment IP and stash support were lower than the scores for the other Stages.

Benefit to Learning based on Delivery Method

The learning benefits of content delivered by methods in this section received a rating of 4 ("somewhat beneficial") or higher for all methods across Stages. Responses for VR events with IP, PilotEdge, IFT, and OFT remained constant across Stages with ratings of a 6 ("extremely beneficial"). Similarly, mission flight events' methods of delivery were the same in Pre-Flight and Mission Stage, scoring a 6, while receiving an N/A in the Qualification Stage. Ratings were higher for solo VR and simulator practice, Augmented Reality (UTD with VR headset), and qualification flight events in the Mission than in the Pre-Flight Stage. Conversely, at-home coursework, Avenger modules, in-person lectures, detachment IP and stash support and UTD received lower ratings during the Qualification Stage than in other stages.

Quality of Content based on Delivery Method

SNA ratings for the quality of content delivered by the methodology in this section were a 4 ("somewhat high quality")

or higher for all three Stages. Only VR events with IP and PilotEdge ratings remained constant at a 6 ("extremely high quality"). Other content, including Avenger modules, IFT, Augmented Reality (UTD with VR headset), qualification flight events, and mission flight events had lower ratings during Pre-Flight, but received higher ratings in the Mission Stage. Additionally, at-home coursework was rated the lowest in this section.

Understanding of Expectations

Responses related to this section were at a 3 ("somewhat not clear") or higher across Stages. Ratings for in-person lectures, detachment IP and stash support, VR events with an IP, UTD, and qualification flight events had lower scores in the Qualification Stage than in Pre-Flight, but ratings in the Mission Stage mirrored Pre-Flight or were higher. Conversely, at-home coursework, Avenger modules, and solo VR and simulator practice ratings were highest in the Qualification Stage, and ratings in the Mission Stage mirrored Pre-Flight or were higher. Additionally, Augmented Reality (UTD with VR headset) and OFT received higher SNA ratings in the Mission Stage than in Pre-Flight.

Most/Least Beneficial

In the free-response questions, the support given by IPs was often called out as the most beneficial course delivery method. IP Support aided with questions, coursework context, event planning, and debriefs. Respondents frequently stated VR trainers or VR events with an IP were also beneficial for preparing for an event, addressing skills that were not addressed in coursework, and practicing contingency responses. Although there is no substitute for Mission flight events, especially in the Mission Stage, OFT was highlighted as the most direct method of teaching course materials and was best for developing awareness and stick skills as well as sight picture. Conversely, at-home coursework, Avenger modules and 3D videos were most frequently listed as the least beneficial delivery method, with SNAs stating that there was not enough understanding to make them useful or that going straight to source materials was more informative or more efficient than completing the modules.

Improvement Recommendations

The most commonly recommended types of improvements were changes to training timeline and changes to VR trainers, which were similar to suggestions made in the course materials section above. SNAs requested more classroom time and a more organized grouping of SIM events. Requests included that Contact and Instrument events be separated from each other and grouped into like events. SNAs also suggested more OFT events, a syllabus flow more like the traditional flow, and a change to class times to maximize study time available. VR trainer recommendations included making VR trainers more reliable, adding an instructor microphone, and varying takeoff and recovery locations. Other feedback focused on developing more videos in a coherent way and setting expectations ahead of each Stage and event.

Summary of Content and Delivery Feedback

Based on SNA ratings and comments, content and delivery were rated positively throughout the syllabus. Specifically, engagement with the delivery methods consistently received positive ratings across all three stages. On the other hand, UTD devices were rated most effective in Pre-Flight but provided less benefit for the remainder of training, potentially because SNAs had other methods to practice flight skills that did not require instructor presence. It is important to note that SNAs rated IFTs higher in understanding the material and delivery method's quality of content for the stages following Pre-Flight. This is likely due to instructors leveraging the knowledge from pre-flight into actual practice of specific skillsets in the IFTs. Overall, delivery methods that involved instructor presence (e.g., IP support, OFTs, VR events with IPs) and flight events were deemed most beneficial. Conversely, Avenger modules and 3D videos were less beneficial delivery methods because they were not in-depth enough to support the entire syllabus compared to other methods, though they were still rated positively overall.

6.3.3. Instruction

This section covers the quality of instruction provided by both SIM and Flight instructors on different characteristics of training during Project Avenger. Feedback is presented across Stages within each subsection. Please refer to Appendix 4 for the full tables of results.

SIM Instructors

SIM Instructors received a rating of 4 ("somewhat of an extent") or higher on all attributes in question 22 of the Student Feedback Questionnaire across all three Stages. The highest rated was knowledge of the aircraft at a 6 ("to a great extent") across Stages, while setting clear student performance expectations received the lowest ratings.

In the free-response questions, the most frequent responses to SIM event effectiveness pertained to instructor characteristics, benefits of training events in the traditional SIM devices (i.e., UTD and OFT), and benefits of the traditional SIM devices themselves. All comments on SIM instructor characteristics indicated effective instructors used SIM events for instruction and coaching rather than only testing existing knowledge. Although the majority of comments focused on teaching throughout the SIM event, individual SNAs did call out positive instructor behaviors such as sharing their experiences, giving advice and clarifying concepts during the brief, and teaching during the debrief. Benefits of SIM events include the experience gained before flying, the ability to practice skills in controlled environment, the ability for SNAs to challenge themselves, the use of discussion items, and the ability to make and learn from mistakes. Benefits to traditional SIMs included skills gained from realistic controls or using controls while in full gear, as well as the advantage of having the FMS capability.

The most common responses about what made SIM events ineffective for learning again focused on instructor characteristics, as well as event characteristics and training timeline. Several SNAs mentioned that SIM instructors were resistant to the Avenger program and may have based grades on their resistance to Avenger instead of SNA performance. Other ineffective instructor characteristics included not fostering a learning environment, inconsistent or unrealistically high expectations, and demeaning behaviors. Regarding event characteristics, SNAs commented that there were too many objectives at one time, which led to incomplete events or poor grades. SIM events were also used as tests instead of learning opportunities. Regarding training timeline, there was mention that SIMs were not presented in an effective order. Other comments pointed to redundancy in SIMs, insufficient preparation time before instrument SIMs, not having enough downtime between SIMs, or too little exposure prior to SIMs.

Ultimately, the most common types of recommended improvements for SIM instructors were associated with instructor and event characteristics as well as what the research team classified as "growing pains" (i.e., positive changes that will occur over time as Avenger continues). In terms of instructor and event characteristics, SNAs recommended SIM instructors stop resisting the Avenger Program and promote a learning environment during SIM events. In terms of growing pains, SNAs indicated SIM instructors will need to learn more about the various aspects of the Avenger program and standardize expectations between instructors.

Flight Instructors

Flight instructors received a rating of 6 ("to a great extent") on all attributes in question 22 of the Student Feedback Questionnaire across the three Stages; except for grading in accordance with CTS and setting clear student performance expectations, which were rated a 5 in the Mission Stage. However, these questions had a somewhat high no-response or "N/A" response rate in Pre-Flight due to limited experience with flight instructors during that Stage. Answers to the free-response questions in Pre-Flight were very limited for the same reason.

Across Stages, comments on the free-response question on the most effective flight event attributes were related to instructor characteristics. SNAs stated instructors provided constructive criticism, allowed SNAs to make and correct mistakes, and gave in-depth debriefs on each event. SNAs also highlighted flight event characteristics and benefits unique to Avenger as being effective in the Qualification and Mission Stage. Avenger events provided a better opportunity to learn new concepts and provided introductions to unexpected contingencies. In addition, events that enabled flight splits or joins helped SNAs synthesize previously learned concepts better. Benefits mentioned included getting real experience in the aircraft to practice various scenarios, repetition of flight skills, and learning from mistakes.

In the Qualification Stage, the repetitive Instrument Stage and not allowing SNAs to fail were viewed as characteristics that made flight events ineffective for learning. Responses from the Mission Stage emphasized that required items reduced flexibility

to address student needs during each flight. In addition, longer cross-country trips required more formation work and more breakup and rendezvous, which was not ideal; and having different partners for different flights meant partners had different needs for special syllabus requirements (SSRs) and prevented items from being signed off on certain flights. In addition, growing pains identified in the Mission Stage were practicing with non-Avenger flight instructors who did not understand the syllabus and performing required items not relevant to the aircraft.

Although some students stated no changes were needed because flight instructors are excellent, there was also some mention of improvements needed during flight instruction. Recommendations in the Qualification Stage included allowing SNAs to fail more often, standardizing Formation training, and increasing communication and consistency between IPs. Finally, SNAs in the Mission Stage expressed the need for instructors to have more time to answer questions; identify and correct errors repeated by individual SNAs; and develop consistent grading, expectations, and attitudes. Other notable recommendations include giving each SNA a Mission Stage partner to minimize redundancy in Mission events and creating an overall student profile outside of the Avenger gradebooks that instructors can consult quickly.

Summary of Instruction Feedback

Overall, instruction was rated highly by SNAs, but adjustments were identified for future iterations. Based on comments, both SIM and flight instruction were effective across all stages, highlighting instructor and event characteristics (e.g., events allowing the introduction of contingencies and providing learning opportunities) as most effective. Instruction on flight events received higher ratings than SIM instruction across the stages for questions such as grading, setting clear expectations, explaining concepts, etc. SNAs stated that there is no substitute for live events, in which a variety of skillsets could be practiced and instructors corrected errors in flight and provided more detailed debriefs. Conversely, SIM instruction was criticized for not fostering a learning environment, being less flexible, having too many objectives at one time, and setting unrealistic flight expectations. The main requests for improvements were associated with higher

instructor-to-student ratio and consistency in grading and expectations.

6.3.4. Summary Feedback

Responses from SNAs showed acceptance of the Avenger Program is high throughout training. From the SNAs' experience with the Pre-Flight Stage (*n* = 16), 69% of respondents would recommend Project Avenger over the legacy syllabus, 19% would recommend it with some reservations, and 13% were not sure if they would recommend it; no SNAs responded they would not recommend. In the Qualification Stage (*n* = 6), 100% of SNAs would recommend the Avenger program without reservations. Finally, in the Mission Stage (*n* = 13), 77% would recommend Project Avenger without reservations, followed by 8% recommending it with some reservations, 8% not recommending it with some reservations, and 8% unsure.

In final comments, SNAs believed Project Avenger worked well, potentially because it better prepared them for flying compared to legacy SNAs and helped them develop a strong understanding of Course Rules and communications. The detachment (det) space was also mentioned as advantageous because it encouraged collaboration with other SNAs and instructors. However, there was concern about Avenger's intense schedule and how it caused decrements in self-care and the ability to sleep in many SNAs. Final comments also stated the SIM schedule does not leave sufficient time for addressing weaknesses between SIMs and that having access to all information early on was overwhelming.

In response to "What, if anything, can Project Avenger do to better train or prepare students for success during training?", the majority of SNAs suggested changes to the training timeline, specifically calling out Instrument training (Preflight Stage and Transition Phase). The following changes were recommended by SNAs to improve Instrument training:

- Increase the proportion of the syllabus that focuses on instruments.
- Provide a lecture on plates, briefs, and picking up clearances before instrument SIM events.
- Do not mix Instrument and Contact events in close succession.

- Revise the Instrument training schedule to introduce Area Navigation (RNAV) before teaching how to enter it into an approach.

- Revise the Instrument training schedule to reduce the number of concepts being introduced at one time.

- Imitate the legacy syllabus by providing an Instrument ground school.

- Increase the number of Instrument events in VR trainers.

In reference to the training timeline as a whole, SNAs suggested including more classroom lectures before SIM events, more VR training for procedures, and more repetitions in traditional SIMs. One SNA recommended adding a familiarization flight during the Preflight Stage to improve motivation, and another recommended adding a familiarization flight during SIMs to boost understanding of flying procedures. Increasing time between SIM events when double pumped (i.e., completing two events in one day) and including more grouped events like Pattern Parties with 3-4 SNAs to 1 instructor was also recommended. "Pattern Parties" refers to Avenger events in which multiple SNAs practice flying in a pattern with either an instructor or PilotEdge to simulate ATC.

6.4. IP and Leadership Feedback

The feedback in this section is based on the focus groups conducted with IPs and leadership (N = 9) involved in the first class of Project Avenger. During the focus groups, positive and negative comments were provided for SNA performance, training efficiency, willingness to adopt, instructor workload, use of technology and resources, and notable programmatic feedback. The focus group participants were unanimously in favor of Avenger-style training for all Primary SNAs, with some minor revisions.

6.4.1. SNA Performance

Pros

Focus Group respondents were overwhelmingly positive about the effect of Project Avenger on SNA performance. There was a strong consensus Project Avenger creates a better generalized aviator than legacy training primarily by:

- Exposing SNAs to more realistic and complex scenarios;
- Requiring SNAs to maintain proficiency on skills throughout the syllabus as opposed to one Stage at a time;
- Requiring greater critical thinking, especially during the Mission Stage.

According to Focus Group respondents, Avenger SNAs demonstrated a greater ability to think critically, making and executing appropriate decisions in complex situations and in response to unexpected contingencies. Respondents expect this critical thinking enhancement to manifest in higher performance in Advanced training and beyond. IPs were also able to focus on specific student needs in any given flight and use ITDs as "homework" to address student weaknesses. Due to syllabus enhancements like PilotEdge and ITDs, IPs estimated Avenger SNAs were about four flights ahead of their traditional counterparts due to an increase in communications skills and an understanding of Course Rules during their live flight events. Some of the specific skills Project Avenger SNAs perform better than the legacy program in training include Visual Straight In approaches and discontinued entry. Additionally, the det space encouraged greater SNA engagement with each other and the IPs, as well as study with computer-aided resources (for example, CloudAhoy, ForeFlight, and videos). The SNAs who took advantage of the det space grasped concepts more quickly and exhibited higher performance than even their fellow Avenger students who did not utilize the det space as often.

Cons

Focus Group respondents considered Project Avenger SNA weaknesses to be minor in comparison to their strengths. Avenger developed a generalized aviator at the expense of skills specific to the T-6 aircraft; however, this was a known objective of Avenger because the Navy does not need highly skilled T-6 experts, but instead, aviators better prepared to learn and be successful in their fleet aircraft. For specific skillsets, Avenger students appeared to have the most noticeable decrement in instruments. Avenger class 1 lacked the traditional, organized instrument ground school, relying only on the newly combined contact/instruments methodology (during Preflight Stage and Transition Phase) to convey all the

necessary knowledge. In addition, two of the most difficult portions of Instrument training, the initial Instrument SIM and the Safe for Solo, occurred at the same time, causing SNAs to prioritize one over the other. The IPs stated these issues will be mitigated by creating a more organized approach to ground school for Instruments, as well as providing greater separation between the Safe for Solo and the initial instrument SIM in the training timeline.

It was also stated Avenger SNAs exhibited somewhat of a decrement in general knowledge (GK), which is being addressed in the next round of Project Avenger with the use of a Personnel Qualification Standard (PQS) to ensure appropriate GK for each specific block or Stage in the syllabus. In addition, due to some inaccuracies in the aero model in the ITDs, Avenger SNAs initially exhibited a high flare picture. However, this tendency was eliminated during their first few flights. Respondents believe any performance deficiencies remaining at the end of Primary training are small and will be easy to correct or will not carry over in Advanced training. Finally, Avenger did not improve over the traditional syllabus in angle of attack (AoA) approach training, which was originally intended in Project Avenger development.

6.4.2. Training Efficiency

Pros

In regards to efficiency, IPs stated that Avenger is more flexible than the traditional syllabus in the order and number of events, as well as the maneuvers completed in any given event. In addition, the detachment model meant SNAs were more readily available for unscheduled flights, in which an Avenger SNA with the requisite skillsets for a contingency such as weather could fly in place of an SNA who was unable to fly. One final source of flexibility was the ability for SNAs to practice various skills in the ITD, which enabled them to better accommodate contingencies in live flight events, reducing the number of flight cancellations. These sources of flexibility helped to keep the Avenger timeline compressed, and as a result contributed to training efficiency. Focus group respondents estimated the use of 360 videos in VR headsets and ITDs also allowed IPs to cut out approximately four flights in which they would ordinarily demonstrate maneuvers and flight skills. This

further contributed to training efficiency and a reduction in fuel usage. Finally, Avenger has the potential to eliminate poor aviators earlier in the training pipeline by requiring SNAs to show greater agency and stronger critical thinking skills in training.

Cons

Avenger's unique requirements and opportunities resulted in more complex flights, and therefore unintentionally longer flight times, than legacy training. Consequently, Avenger SNAs completed roughly the same number of flight hours as legacy SNAs, in spite of fewer flight events. However, respondents expect to be able to reduce the flight hours while maintaining performance by reducing redundancies in the syllabus, and intend to do so in classes 2 and 3. Upon executing the syllabus, several SSRs were found to be redundant across numerous events; a rework to eliminate those redundancies was conducted prior to class 2. SNA and IP wait times for available ITDs and SIMs reduced efficiency. To address this lag, there is a plan to split the second class into two groups set to begin roughly two weeks apart which would remove, or at a minimum reduce, the wait time for available ITDs.

6.4.3. Use of Technology and Resources

Pros

The focus group stated time and resources were largely sufficient for SIMs and live flights; in fact, IPs thought live flight time may have been higher than necessary to reach proficiency due to redundancies and scheduling inefficiencies. Therefore, better scheduling and eliminating redundancies should allow SNAs to reach necessary proficiency in fewer hours in future iterations. Resources such as a full library of 360 videos and MR upgrades to the UTDs were limited or not available for the first class, but are planned for future iterations. Given the current state of the technology, IPs felt ITDs, legacy SIMs, 360 Videos, and PilotEdge were used to their best advantage, although greater realism in the ITDs (especially aero model accuracy and trim), the capability to link OFTs for formation flights, and extending the PilotEdge ATC capacity and hours would make Avenger technology more useful for training throughout the syllabus.

Cons

Avenger SNAs exclusively used electronic publications; respondents thought a brief introduction to paper charts would be beneficial for future SNAs, especially if they will be used in Intermediate and Advanced syllabi.

6.4.4. Willingness to Adopt

Pros

Focus Group respondents strongly believe Project Avenger is the right way to train all Primary SNAs. They stated that, although resistance exists outside of Avenger, instructors who have discussions with Avenger IPs or who join Avenger flight events consider Avenger a benefit to training. Thus, there is the expectation that willingness to adopt Avenger will be high once it is added to the normal flight schedule and as understanding of Avenger is increased over time. Respondents also indicated standardized training of IPs may increase adoption and decrease frustration and misunderstandings surrounding the new training program.

With regard to instructor preparation and workload, respondents mostly stated they were as prepared as they could be for a new program, and gaps in preparedness will be addressed over time with changes in the Flight Instructor Training Unit (FITU) training and experience with Avenger. Although the IP teaching workload is high (e.g., longer briefs, flights, and debriefs), the work is more rewarding, because IPs are attached to a specific class and can see their SNAs improve over time. This differs from the legacy syllabus, in which IPs may only see an SNA for a single event.

The Detachment model was also seen as a great benefit for Project Avenger. It created a close-knit team in which SNAs and instructors helped struggling SNAs, and instructors helped one another. Overall, respondents believed there are no good substitutes for the immediate, face-to-face support received from instructors. The Detachment model also made training more rewarding for IPs, as they were able to watch SNAs’ progress from start to finish. Although there was some concern that a scaled-up version of Avenger would allow some less effective detachments to occur, it was suggested IP training emphasizing the detachment model would minimize the risk.

Cons

Focus Group respondents believed most of the resistance to Project Avenger comes from a lack of understanding of the program's purpose and structure. This includes the misinformation that Avenger only exists to cut flight hours, some SIM instructors expecting Avenger SNAs to be more seasoned pilots than they were during SIM events, and awareness of how cumbersome the gradebooks are to utilize.

In addition, IP workload was stated as higher for Project Avenger than for legacy training; the previous normal of a 10-12 hour day becomes a 12-14 hour day in Avenger. The increase in IPs' ground task load causes fatigue and could discourage high-performing IPs from working in Primary training. Focus Group respondents recommended dedicated Operations, Scheduling, and Student Control (STUCON) personnel to complete ground tasks and route paperwork while IPs are flying. They also stated they need a usable, mobile-enabled LMS and gradesheets to replace the Excel-based gradebooks required in Class 1. This would allow IPs 24-hour access to log and monitor SNA syllabus progression.

Respondents also identified a number of minor issues that were either carryovers from the Air Force's Banzai (UPT 2.5) syllabus or the result of a new program in its infancy. For example, some maneuvers in the gradebooks do not exist in Navy training and IPs were not certain how to rate difficulty in events consisting of maneuvers that were never flown before. These issues are either being addressed through changes to the syllabus and gradebooks, or will be mitigated as IPs gain experience with Avenger.

Finally, if Project Avenger is targeted for scaling up, infrastructure and the cybersecurity policy must be addressed as soon as possible. NAS Corpus Christi and Whiting Field, homes to all Navy Pilot Primary flight training, do not currently have the infrastructure to support Avenger at a large scale and will likely take years to develop it. The current cybersecurity policy also makes the IPs' workflow inefficient and should be adjusted to give IPs more flexibility; for example, by allowing mobile data entry. Finally, Avenger's high repetition of formation flights will likely cause an increase in sympathetic aborts due to maintenance limits on aircraft tires. Tire

maintenance processes may need to be updated to minimize this efficiency issue.

6.4.5. Additional Feedback

Focus Group respondents recommended IPs be given even greater flexibility in future iterations to address individual SNAs' needs and to change events to increase difficulty in student profiles. They also recommended the following changes to the current Avenger syllabus:

- Increasing ground school time by approximately four hours (will be instituted in class 2).
- Adding the traditional program's Visual Flight Rules (VFR) Lab on Vertical Navigation (VNAV) planning.
- Moving at least one ITD into the det space and asking SNAs to return the VR headsets after 6 weeks to make them available for studying in the det space.
- Increasing standardization in specific areas of the syllabus such that SNAs cannot complete aerobatic maneuvers before basic flight skills and SNAs are able to fly similar profiles in the Mission Stage.
- Changing the order of Day Contact events such that classes precede ITDs and ITDs precede SIMs, to create a crawl-walk-run progression.

In addition to these Avenger-specific changes, respondents noted future SNAs who go through Avenger-style training may be at a disadvantage in aircraft commander ratings compared to traditional SNAs due to a potential decrease in flight hours; the Navy may need to consider changing flight hour requirements.

7. Discussion

Overall, Project Avenger shows significant promise as an effective way to train a more generalized aviator, better prepared for training in follow-on aircraft. SNAs who participated in Avenger demonstrated high critical thinking

skills and flexibility and were able to complete training in fewer flights and shorter time than their legacy counterparts. In addition, both IPs and SNAs expressed that the new technologies integrated into Avenger training were beneficial, although they identified ways to further develop and improve them. Even though there are needed improvements, instructors and students still overwhelmingly recommend the new syllabus as the future of aviation training. Below, findings are discussed in greater detail as well as potential underlying factors for these results.

Although the results imply that Project Avenger will provide considerable cost savings when scaled across Primary training, the research team did not conduct formal analyses of cost for this report. This is because of the small sample size for Avenger class 1, the current lack of data about Avenger's effect on Advanced training, and the fact that a number of already-identified changes will be incorporated into the Avenger syllabus in upcoming classes. When Avenger has a higher number of graduates from multiple classes and the graduates have continued further into training, a more accurate cost analysis can be conducted.

7.1. SNA Performance

This evaluation examined differences in performance between Project Avenger and legacy SNAs. For the overall score across the syllabus, grade received (ERS) was lower for Project Avenger SNAs than for legacy SNAs. This may seem paradoxical on surface examination, but the divergent nature of the syllabi's training philosophies along with infrequently used difficulty weightings amply explain the performance outcomes. Future iterations of Project Avenger should identify an appropriate method to account for its greater difficulty, either by encouraging or mandating the use of the current difficulty weighting system or finding an alternative way for scores to accurately reflect when SNAs challenge themselves.

Looking at the Mission Stage specifically, Project Avenger SNAs received lower scores on M4000-level flights and checkrides than legacy SNAs on their advanced flights and checkrides. Again, this should be expected when examining the specific nature of the flights: the legacy "equivalent" events occur when SNAs are expected to display proficiency on specific technical skillsets

they have focused on for that block of training, whereas Avenger Mission events are geared toward training adaptability, critical thinking, and situational awareness while performing the technical skillsets adequately. This can result in Avenger SNAs receiving lower grades while performing more complex flights due to the majority of grades being based on the technical skills rather than mission skills. Additionally, Avenger allowed for a wider selection of potential maneuvers to perform during the Mission Stage compared to the targeted skillsets in legacy block training, meaning the Avenger SNAs may be performing maneuvers they have not practiced recently. By contrast, legacy SNAs have recently practiced the skillsets needed for their flight and therefore are better prepared to receive higher grades. Finally, Avenger had fewer flight events overall, meaning that these complex, mission-style flights were being performed by people who had fewer opportunities to practice overall. In an attempt to account for this, the research team used a few different counts of graded events in the syllabus as covariates; although the numbers of flights and graded events were significantly lower for Avenger SNAs, accounting for them did not change the pattern of results.

In the Mission Stage checkrides (events M4190A and B), Project Avenger scores were again lower than legacy scores. This pattern did not change when the number of unique maneuvers completed in the checkrides was used as a covariate, although the number of unique maneuvers was significantly higher for Avenger than for legacy SNAs. This indicates, as expected, more complex checkride events in Avenger. Thus, the Mission Stage pattern of performance indicates worse performance for Project Avenger than for legacy SNAs, but with fewer prior events while completing more complex flights, and with several additional reasons based on syllabus design and theory outlined below.

Overall, the performance results appear to indicate legacy SNAs receive higher scores than Avenger SNAs. However, examination of the most comparable individual events from the Qualification Stage, as well as understanding the culture and changes Avenger is implementing, tells a more complex story. As predicted, Project Avenger SNAs started out with lower performance scores, but on some specific, more complicated events, caught up to and surpassed their legacy counterparts. Specifically, on both formation and cross-country events, events requiring more complex or broader skillsets, Avenger SNAs received higher

grades than their legacy counterparts and did so with fewer events leading up to these flights. This indicates that Project Avenger is meeting one of its prime objectives: to create better generalized aviators, not narrowly-focused T-6 experts.

Another point to be aware of are idiosyncrasies to the MPTS grading system. Due to the grading schema (Grade/MIF), the more SNAs challenge themselves or attempt more maneuvers, the more likely they will receive lower overall grades (i.e., grades equivalent to MIF or below resulting in scores of one or below instead of scoring one or two points above). This occurs because taking on new or challenging maneuvers will result in higher counts of those closer-to-one or below grades, driving overall scores lower. Encouraging SNAs to challenge themselves via new and/or more maneuvers instead of attempting well-practiced already-proficient maneuvers unintentionally lowers their overall scores. Therefore, Avenger's approach and culture naturally pushes SNAs towards lower scores based on the current grading schema.

Additionally, the pattern of results during the Qualification Stage was anticipated in the development of Project Avenger based on the research literature on developing complex habits and skillsets. Results from Lally et al. (2010) showed that habit formation takes longer as habits become more complex, with complex habits taking as long as approximately six months to establish. Based on this, the Avenger team believed the repetition of skillsets across the syllabus, rather than within a single phase or block, and the greater variability in learning events in Avenger's competency-focused training would lead to better habit formation of the complicated skillsets required in aviation training. By contrast, the criterion-focused legacy syllabus can lead to peaking of block-specific skills that are repeated frequently in a short time period, followed by skill decay due to lack of or infrequent repetition across the longer time period necessary to form a habit. Figure 3 provides an illustration comparing legacy and Avenger theoretical learning curves and habit formation.

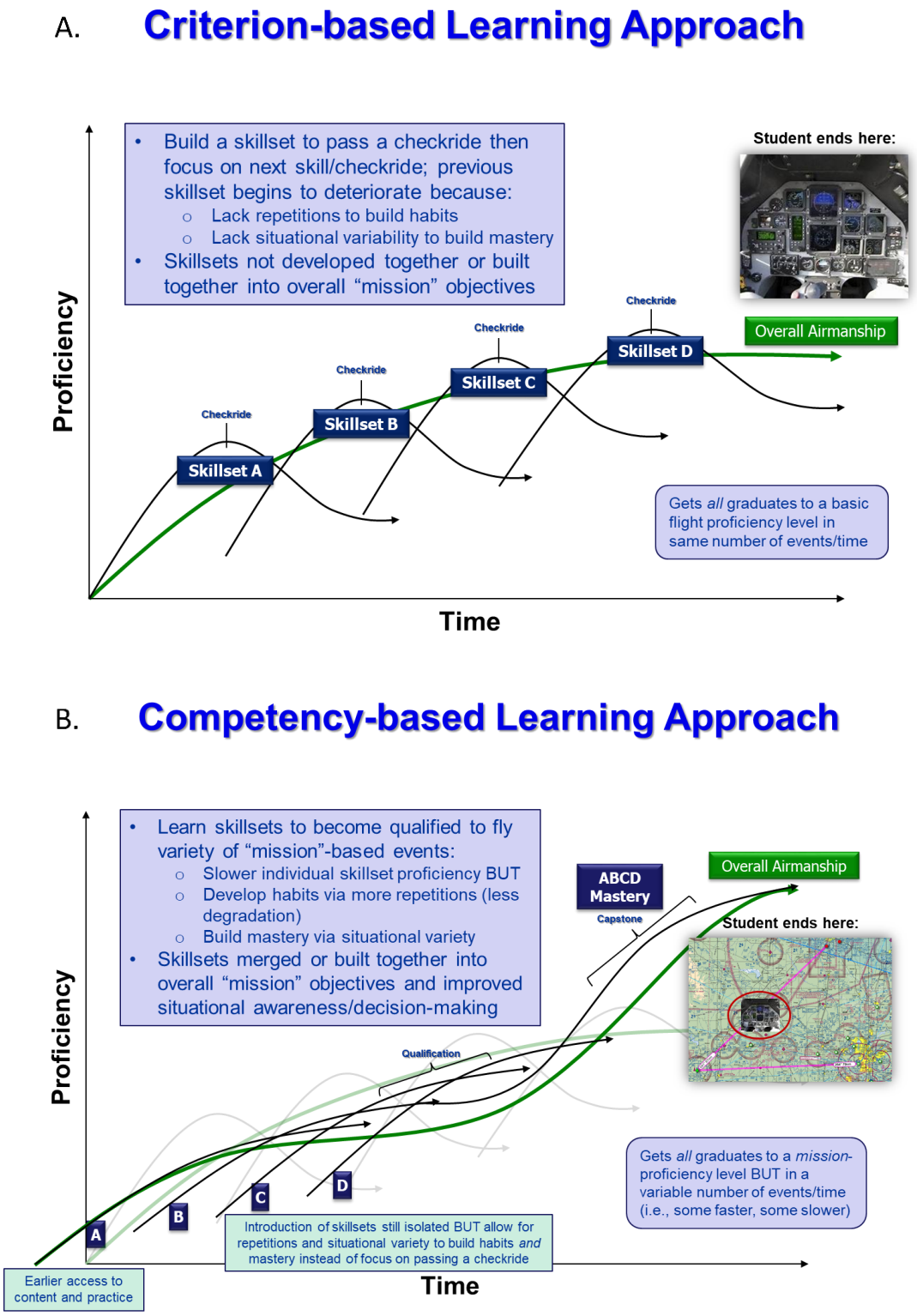

Figure 3. Illustration of (A) legacy and (B) Project Avenger theoretical learning curves

Another aspect from the training and learning research literature leveraged by Avenger but likely subduing results is the benefit of situational variability. Research shows practicing skillsets in a wider variety of situations leads to stronger learning, knowledge retention, and skill mastery (Bjork & Bjork, 2019; Lee & Magill, 1983; Shea & Morgan, 1979). In training with high situational variety, immediate performance on skillsets in a new scenario may be lower than performance in a familiar scenario, but longer-term performance and learning are higher with high-situational-variety training compared to training with lower situational variety. Exposing SNAs to a wider variety of situations is a focus of Project Avenger and the main premise of the Mission Stage in particular. However, this approach can lead to lower graded performance for Avenger compared to legacy grades. SNAs in the legacy training typically will do the same, or highly similar, flight profiles (i.e., maneuvers, in same airspace, same flight path, etc.) in each block of training, allowing them to maximize their grades with the high repetition and similarity of events. In Avenger, however, SNAs go through greater variety, making it more difficult to maximize grades but providing greater opportunity to fully master skillsets. Because of this, Avenger SNAs are likely to receive lower grades while trying to master skillsets across situations versus legacy SNAs who only practice a single situation.

As a result of Avenger's unique approach, early events should show an advantage of legacy training, when in-block skills are repetitive and performance can peak, whereas Avenger events are variable and trainees are developing skill mastery. Later events, by contrast, should start to display the advantage of Project Avenger, when situational variability and mission-style training develop higher overall competency to surpass the individual skillset peaks in legacy training. Prior to the Mission Stage, performance results conform to this pattern, but Avenger SNAs show worse performance again in the Mission Stage.

A potential reason the results here do not fully reflect the theoretical model is the lack of true comparison events. The research team did their best to identify close approximations but, there are no true close equivalent events in the legacy syllabus, especially for the Mission Stage. Additionally, the

instructional styles and objectives within the Mission Stage do not have an equivalent in the legacy syllabus. While knowing this, the research team worked with SMEs to identify legacy events that could be seen as roughly comparable to M4000 and M4190 events to offer some type of comparison. They then used the maneuvers from all M4000 events (Avenger) and all comparison events (legacy) to create artificial "Advanced Flights" events, calculating unweighted ERS using the same formula used for real events. The same method was used for M4190 events to create artificial "Checkride" events (see Table 3 on page 28 for the list of comparison events). However, the events may still have been too different for accurately comparable grades to occur. In part, this is once again because Project Avenger is focused on creating a generalized aviator mastering the underlying behavioral competencies (e.g., mission planning), whereas the legacy syllabus is focused on technical skill proficiency specific to the T-6B aircraft. In addition, the legacy syllabus events used for comparison focused on maneuvers specific to a block of training, meaning the graded maneuvers had been learned and practiced frequently and recently. By contrast, Project Avenger SNAs had much greater variability and were expected to be able to perform any maneuver they had learned throughout the syllabus. Because of this, Avenger SNAs were attempting maneuvers in the Qualification and Mission Stages they may not have encountered recently or practiced as frequently as legacy counterparts. As mentioned above, this leads to lower grades due to a greater number of maneuvers grades at or below MIF. Project Avenger also established an entirely new type of training event with the Mission Stage to develop a better overall aviator, and follow-on Advanced training results will need to be examined to understand its effects.

Beyond the theoretical considerations, additional circumstances may also have contributed to this pattern of results. First, IPs indicated Project Avenger SNAs had been in training for a shorter length of time than legacy SNAs when they started comparable events early in the syllabus; that is, they were less experienced than their legacy counterparts. Although this does not necessarily explain the lower scores on M4000-level events, it may contribute to their lower scores on the first two Qualification Stage events analyzed for this report (i.e., last simulator event and first flight). Added to this is the flexibility of Project Avenger events, wherein any maneuver may be attempted as long as the IP considers the SNA capable of

attempting it safely. It is possible this flexibility led to less experience in any one specific maneuver than would have occurred in the more rigid and repetitive (within block) legacy syllabus.

Second, although difficulty weightings were set up as a way to compensate for Avenger's added challenge via boosted grades, they were not employed as consistently, frequently, or aggressively as may have been warranted by the difficulty of maneuvers or events. Project Avenger SNAs who attempted a larger number of maneuvers in the Mission Stage, potentially challenging themselves with higher-difficulty or more complex events, received a lower overall ERS than those who attempted a smaller number of maneuvers, even when using difficulty-weighted ERS. This indicates the difficulty-weighted scores may not be sufficient to compensate for increases in event difficulty. This also appears to be supported by the low number of difficulty weightings: on average, Avenger SNAs received non-zero weightings on only 17 maneuvers across the entire syllabus. Again, if an SNA attempts more maneuvers and more difficult maneuvers, as they are encouraged to do in Project Avenger, and they perform at or below MIF (likely when challenging oneself), it will pull their grade lower. Thus, difficulty weightings must be employed more frequently and aggressively to counteract the effects of the number of maneuvers and their difficulty.

Third, the MIFs employed in grading, even in Project Avenger, may still be too heavily focused on specific manual skills with too little focus on the behavioral competencies (e.g., critical thinking, good decision-making, and contingency response- all training goals of Project Avenger). Especially in the Mission Stage, Project Avenger SNAs were flying complex missions with unexpected contingencies injected, but the majority of the graded maneuvers maintained the requirement to demonstrate specific skills (e.g., "in-flight checks" and "full-stop landing"). Far fewer maneuvers were dedicated to Project Avenger-specific goals such as "risk management." Therefore, the graded content likely favored legacy SNAs. This is especially true because the technical skill-based content favors the block style of legacy training, in which SNAs focus on and repeatedly practice the manual skillset required to pass and exceed MIFs on their upcoming flights. Again, this makes it easier for legacy SNAs to receive high grades early on, whereas Avenger SNAs were

often practicing a multitude of diverse skillsets in any given event.

Finally, comments on the questionnaire and during the focus groups from both SNAs and IPs indicated some non-Avenger instructors lacked understanding of the Project Avenger syllabus, grading requirements, and performance expectations. This may have led to inflated expectations of performance for earlier syllabus events, in turn influencing them to give lower grades than warranted. This led to several SNA comments suggesting SIM instructors be taught about Project Avenger in order to calibrate their expectations prior to assessing events.

Taken together, these circumstances suggest Project Avenger SNAs performance is not accurately reflected in grades when directly compared to legacy and they may have received scores underestimating their actual performance, or current methods do not appropriately assess their mastery of the skillsets Avenger focuses on. This is supported by the strongly positive feedback of Project Avenger-involved IPs and leadership, who want all future SNAs to have access to Project Avenger-style training and consider the Avenger SNAs better prepared for follow-on training and the Fleet than legacy SNAs. It is also reflected in two SNAs' comments that their Naval Standard Score (NSS) was lower than it should have been, considering their own understanding of their performance. In all, given the grades Project Avenger SNAs did receive, they had lower overall ERS than legacy SNAs, but higher scores on some individual events.

This evaluation only examined Primary syllabus performance, but a better measure of success will be performance in Advanced training. IPs and leadership believe Project Avenger will lead to significant performance advantages for its SNAs in Intermediate and Advanced training as well as in the Fleet as full-fledged aviators. A full understanding of the effects of Project Avenger will require analysis of performance as Avenger SNAs complete more advanced training syllabi, and possibly as they continue in their careers in the Fleet. These analyses will inform the Navy on the robustness of NATN syllabi: does the expense of creating and administering these new syllabi really lead to better aviators throughout their careers, or do any advantages dissipate too quickly to be of use?

7.2. Efficiency

Overall, Project Avenger was more efficient than the legacy syllabus. The team calculated time to train as the number of months elapsed between the first simulator event and the last graded event within the datasets. Results showed time to train was shorter for Project Avenger, even when legacy SNAs had four of their flight events waived. This aligns with CNATRA's internal analysis, which found Project Avenger was completed 8.5% more quickly than legacy training. The number of flights and overall number of graded events (SIM and flight combined) prior to solo were also lower for Project Avenger than for legacy training, in alignment with CNATRA's finding that Avenger required about 5 fewer flights to reach the Safe for Solo milestone. Number of SIMs and flights prior to cross-country flights were also lower for Project Avenger than for legacy training, indicating Project Avenger SNAs reached milestones more quickly than legacy SNAs.

In addition, several different counts of events completed were calculated, including reflys and extra events such as warmup sorties. Due to the large number of ITD (VR trainer) events, Project Avenger had a larger total number of events than legacy training; however, the number of flights and SIMs (UTDs and OFTs combined) were lower in Project Avenger than in the legacy syllabus. Thus, the number of relatively costly training events were lower for Project Avenger than for the legacy syllabus. In part, this may be due to the heavy usage of ITD events, allowing SNAs to enter their later UTD and OFT events with skillsets already partially developed; as well as obtain practice on skillsets the legacy syllabus does not provide tools for practicing outside the aircraft, such as formation flying. Importantly, the number of ITD events in Project Avenger did not make its training timeline longer than the legacy syllabus. The relatively high number and availability of ITDs compared to the UTD and OFT may have contributed to this result; it is easier to pass a large number of students through ITD events in a short amount of time than to do the same in the limited number of UTDs or OFTs. High availability and the ability to house a large number of devices in a relatively small training space are two reasons VR trainers are being explored throughout the military to enhance training efficiency.

Finally, extra events (reflys; adaptation, practice, warmup, and supplemental sorties, progress and elimination checkrides; extra training; and warmup events other than warmup sorties) were counted to determine any differences in efficiencies. Descriptive results showed that though the total number was similar between the two syllabi, they did differ in the types of extra events completed: Project Avenger had more reflys and legacy had more warmup sorties. The reduced number of warmups gives additional support to Avenger's greater efficiency as these types of flights are utilized when SNAs have not been able to fly within allotted timeframes. Avenger having fewer warmups indicates that its flexible structure allows flights to be completed when legacy's more rigid approach would not allow it.

In the focus group, IPs and leadership stated that they expect to further increase efficiency in classes 2 and 3 of Project Avenger. They intend to do so through better understanding and utilization of Avenger's proficiency-based model (i.e., moving the SNA along when demonstrating necessary proficiency on a skill, by developing more effective learning events which will reduce the average flight hours needed to reach proficiency per SNA). Additionally, IPs identified an intention to improve scheduling to eliminate redundancies in SSRs, especially on events with other SNAs who may require different SSRs. CNATRA also reported they are updating the FITU to qualify all instructors across all stages of primary training. Currently, instructors do not achieve all qualifications, with Formation being the least common. Expanding qualifications will improve availability of instructors across all Primary training and enable faster progression via greater IP availability throughout the syllabus. Finally, focus group respondents were optimistic Project Avenger-style training, which requires SNAs to self-direct their training more than the legacy syllabus, could lead to earlier attrition among SNAs not suited to become pilots. If true, this would lead to reduced time and money dedicated to training students who will not become pilots, freeing resources for additional trainees. Continued analysis of future iterations of Project Avenger should be conducted to confirm these findings and determine if efficiency has increased further.

7.3. Technology

Project Avenger introduced emerging low-cost technology into training while standardizing the use of technology available,

but not provided by the legacy syllabus. For example, although some software packages like ForeFlight and CloudAhoy are available for, and used by, legacy SNAs, they are personally procured by the SNA via their own resources. With Project Avenger, these technologies are embedded in the curriculum and accessible for use at no extra cost to the SNA. Overall, IPs and SNAs provided positive feedback on the accessibility of all the training modalities used by the program and stated that most were relevant across all three stages. These technologies (e.g., 360 videos, iPads, Oculus) provided SNAs early and continuous access to immersive flight content that they could interact with at their own pace and on their own time. Other technologies such as PilotEdge enabled SNAs to practice their flight communication earlier, more frequently, and in a more immersive environment, which provided them with stronger communication skills earlier than their legacy counterparts. This was such an advantage that future iterations of Project Avenger will look to expand its availability and/or into synthetic alternatives.

Additional technology emphasized by respondents were the ITDs. Specifically, having access to these devices helped SNAs prepare for their SIM and flight events and provided IPs another option for remediation of SNA flight skills. Although these devices received heavy usage, IPs and SNAs identified some areas for improvement to increase their benefits to training:

- Improving the accuracy of the ITDs' T-6B flight model, especially the trim, will enhance their effectiveness for practice. This will improve practice for the Mission Stage, when practicing basic formation skills in the ITDs would help SNAs balance flying with problem solving while in the actual aircraft - currently somewhat limited due to model inaccuracies. CNATRA's report agrees, noting the lack of realism in control response and switchology.

- Making the location of switches on the ITD HOTAS match switches in the real aircraft will reduce the risk of negative training for manual flight skills …. This is being addressed by NAWCTSD, which is developing and building T-6B replica HOTASs for use in the ITDs.

- Improve the reliability of the ITDs. Given that perceived usability of a VR system affects trust in it (Salanitri et al., 2015) and trust affects use of technology (e.g.,

McKnight, Carter, Thatcher, & Clay, 2011), increased reliability is an important component of encouraging SNAs to use the ITDs for self-study. CNATRA's report also noted the unreliability of the ITDs and recommended further development to improve them. They report developers are cooperating with them to address reliability problems, but efforts should include the creation of a default startup setting easily loaded across multiple machines simultaneously after each SNA use.

In all, technologies introduced in Project Avenger had a huge impact facilitating development of generalized aviators in a compressed timeline and helped drive a successful first Avenger class. The syllabus enabled greater access to flight trainers and Avenger's design capitalized on ITD strengths and mitigated weaknesses (McCoy-Fisher et al., 2019) to facilitate effective practice, while software applications and hardware updates helped SNAs better prepare for flight events as well as provide feedback on performance. These systems ultimately helped to minimize the lags specifically related to SIM availability in the legacy training.

7.4. Willingness to Adopt

Feedback from both IPs and SNAs was overwhelmingly positive. IPs and leadership unanimously agreed Project Avenger is the right method for training all future Primary classes and creates a better generalized aviator than legacy training, and most SNAs responded they would recommend Project Avenger to future SNAs. These comments indicate Project Avenger was highly successful in developing strong aviators; and participants in Project Avenger, both student and instructor, recognize its advantages. Non-participants also seem to recognize its advantages once they were better informed of the program.

Interestingly, the positive feedback from participants is only partially supported by the performance data, which showed lower overall grades for Avenger and mixed results when examining grades on individual events. As discussed above, there are several circumstances which may explain why grades were lower for Project Avenger SNAs. Future evaluation of Project Avenger graduates in advanced training is needed to determine if the expected advantages hold true.

SNAs and IPs largely agreed in their feedback, including the following points:

- Some non-Avenger instructors were resistant to Project Avenger, although familiarity with the program tends to reverse their resistance.

- ITDs were incorporated into the syllabus to great advantage, although the devices themselves could be improved.

- The detachment model was very beneficial for learning.

- Future iterations of Project Avenger should include a better-organized Instrument ground school.

- Lower grades and flight hours could put Project Avenger graduates at a disadvantage, indicating a need for changes to grading and rating systems as NATN syllabi scale across training.

- SIM events should be treated more as learning opportunities in which SNAs are coached rather than tested on performance; a response in line with Project Avenger's goal of encouraging SNAs to challenge themselves, as it would make it safer for SNAs to try new or difficult maneuvers during SIM events.

In addition to the points of agreement outlined above, SNAs frequently stated that the MCG was difficult to use and inaccurate, resulting in lower usage than other materials and indicating a potential need to update it. This is likely partially due to having to create an entirely new MCG incorporating brand-new training concepts, syllabus flow, and grading systems (i.e., difficulty ratings, root cause analysis). However, as SNAs progressed through the syllabus, they did rate it more favorably in later stages. Future evaluations of subsequent classes should examine if this feedback continues after MCG updates.

Comments from IPs emphasized their workload as being much higher for Project Avenger than it is for the legacy syllabus, estimated at two extra hours per day of work. The reward of watching SNAs learn how to fly made the higher teaching workload

worthwhile; however, the higher administrative workload was undesirable and could lead to IP burnout, deterring IPs who might otherwise wish to work in Primary training from doing so. A study of physician burnout found longer hours led to more burnout, but the effect was mediated by their perceived workload and their sense of autonomy in their work (Shirom, Nirel, & Vinokur, 2010). This suggests Avenger IPs who are required to take on the extra ground task load may, through higher perceived workload and low autonomy, become burned out more quickly than legacy IPs. Therefore, addressing the need for dedicated personnel and easier grading may be important for the success of Project Avenger.

These comments, as well as some more minor points from IP, leadership, and SNA feedback, point to several areas in which recommendations can be incorporated to improve Project Avenger and maximize the benefit of NATN's new syllabi.

7.5. Recommendations

Results indicate Project Avenger was a success overall, but also identified areas for improvement. Based on the data collected and results from this evaluation, the research team provides the recommendations below to improve Project Avenger and similar programs. These recommendations cover grading, training efficiencies, instructor support, and several other small areas and are meant to provide guidance on where and how to optimize NATN syllabus efforts.

Additionally, the research team reviewed CNATRA's internal evaluation of the first class of Project Avenger and has noted where there is concurrence in recommendations as well as any differences between this study and CNATRA's report. Overall, recommendations from both reports are in agreement, and there are no topics with conflicting conclusions. However, with the differences in the types of data available, what and how analyses were conducted, and focus of the evaluations, there are a number of recommendations in each evaluation not covered by the other report.

7.5.1. Grade Differences

As discussed above, results show Project Avenger SNAs receive lower overall grades than their legacy counterparts. As this new training is expanded and scaled, CNATRA will need to find better

ways for comparison to legacy students for fair and appropriate assignment to follow-on training (i.e., strike, rotary, or multi-engine advanced training). Grading should be re-examined and updated to reflect the new, broader learning structure of Project Avenger (legacy's narrow skillset development vs. Avenger's broader, behavioral-focused approach). The broader approach in Project Avenger can result in lower overall grades as the SNA works to achieve proficiency across a greater number of skills compared to the legacy approach of focusing on a limited number, reaching proficiency, then moving to the next set (and potentially having the initial skills deteriorate from less practice). Things to be considered to ensure accurate grading and student comparisons for pipeline assignments include:

- Maneuver difficulty weightings should be employed more frequently and consistently, or a different measure to account for difficulty should be identified. A potential alternative measure is the number of maneuvers attempted during an event, although this too has limitations. To some extent, this need may be addressed by instructors learning to calibrate their difficulty estimates as they continue in Project Avenger. The need to adjust difficulty weightings was also noted in CNATRA's report, which suggests standardizing difficulty weights as a potential means to improve the weighting method. As Project Avenger matures further in coming iterations, adjustments should be standardized into an Avenger-specific, norm-referenced, and difficulty-weighted metric that is validated against Advanced Training performance, emphasizing Avenger's focus on training SNAs for performance beyond the T-6B aircraft.

- Graded items should be modified to account for Project Avenger's greater emphasis on critical thinking rather than simple maneuver performance. Adding additional graded items or changing the proportion of the graded items are potential options. For example, lists of maneuvers could be modified to contain a larger proportion of items that measure critical thinking, such as "contingency response." Alternatively, good critical thinking performance could earn rewards added onto the base ERS, in a similar manner to difficulty weightings, or maneuvers could be differentially weighted within events according to importance.

- Until a valid and reliable Avenger-specific performance metric is established, create Advanced pipeline selection processes that do not require minimum NSS (e.g., selection for Strike pipeline currently requires an NSS of at least 50 in legacy syllabus).

Beyond the above, CNATRA's report recommends reverting to maneuvers with a specificity level similar to legacy training. Project Avenger broke down several maneuvers to higher levels of specificity to more accurately assess SNA performance trends; for example, "Breakup and Rendezvous" for legacy training was broken down into "Breakup" and various types of rendezvous maneuvers in Project Avenger. The higher specificity allowed more targeted assessments but increased instructor workload, and instructors stated that the value added did not justify the workload increase. CNATRA reported for classes 2 and 3 they reduced specificity while maintaining the critical thinking maneuvers from the first round. The research team concurs with CNATRA's approach, but also recommends increasing the proportion of maneuvers that cover critical thinking skills.

Lastly, if proficiency is maintained or increased and average flight hours completed decrease in future iterations of Project Avenger or other NATN syllabi, then the Navy and Naval Aviation Enterprise will have to consider changing certain qualification standards such as aircraft commander ratings, which currently rely on flight hours completed. Without changing the requirements, SNAs who go through these new syllabi may be placed at a disadvantage in their careers when trying to attain specific qualifications, positions, or promotions.

7.5.2. Encouraging SNAs to Challenge Themselves

Another advantage of addressing potential grading discrepancies, as discussed in the previous subsection, is to ensure SNAs are encouraged and incentivized to challenge themselves to drive learning and skill mastery, a major component of Project Avenger. Currently, the risk to their grades could be a disincentive to engage in any challenging events or maneuvers.

Additionally, SIM and flight instructor training should emphasize syllabus flow (non-checkride) events be treated as much as learning events as possible, rather than focused on evaluations or tests of performance. Grades should be used to guide SNA development and feedback for improvement, not solely

as an evaluative process. Instructors should coach SNAs through the events according to the individual SNA's state of knowledge; SNAs are expected to be prepared for the event, but instructors should work to make it as valuable to learning and development as possible. This will help encourage SNAs to challenge themselves by creating a learning environment in which it is safe to push oneself and potentially make mistakes; SNA failures obviously need to be caught, addressed, and corrected, but should also be used to teach and push SNAs beyond current capabilities. The SNA should be focused on learning and have less reason to fear their grades will be negatively affected by attempting something new or difficult.

7.5.3. Improving the Training Timeline

From IP feedback, the order of events should be modified to more closely follow the crawl-walk-run training model. For example, focus group respondents stated the Day Contact portion included SIMs before classes; instead, it was suggested Day Contact training should begin with classroom events, continue into VR (i.e., ITD) events, and then continue into OFT events, rather than switching around between the three. In addition, IPs recommended greater standardization within the syllabus such that SNAs cannot attempt aerobatic maneuvers before learning basic flight skills. Although this technically reduces the flexibility of Project Avenger events, it maintains a reasonable amount of flexibility while ensuring SNAs learn minimum basic flight skills before they attempt potentially unsafe maneuvering.

Instrument training should also be re-examined and expanded. The CNATRA report specifically called out instrument navigation (INAV) as a portion of the syllabus needing to adjust to more of a crawl-walk-run progression; this was addressed for classes 2 and 3. SNAs and IPs both recommended developing a dedicated, organized Instrument ground school to fill the current gap in training. This instrument-focused portion of ground school would improve understanding and performance during SIM and flight events; it would also likely boost grades on some maneuvers. Additionally, the Instrument timeline was perceived as too fast, with not enough classroom training, and with two of the more challenging parts of Primary training (Safe for Solo preparation and initial Instrument SIM) occurring at roughly the same time. IPs recommended separating Safe for Solo and the initial

Instrument SIM to prevent SNAs from prioritizing one over the other and missing out on learning opportunities. This convergence of the two events was listed as Project Avenger's greatest weakness in CNATRA's report, along with the caveat that Avenger SNAs received more time in Instrument training than their legacy peers. Finally, IPs recommended using the legacy syllabus's VFR lab on VNAV planning to teach SNAs VNAV planning skills and improve overall instrument performance.

IPs also recommended eliminating redundant SSRs to maximize training efficiency, a step taken for the second and third classes of Project Avenger. Several SSR redundancies occurred because SNAs complete Mission Stage flights in partnership with the other SNAs, and often one SNA needs to fulfill SSRs already fulfilled by the other. This inefficiency could be addressed by assigning one partner throughout the Mission Stage to each SNA. Alternatively, it could be addressed by standardizing the syllabus such that all SNAs are flying similar profiles, at least for SSRs, in the Mission Stage.

7.5.4. Supporting Instructors

CNATRA should provide training and education across the Training Wings on NATN's initiative and the way Project Avenger's objectives and methods are aligned. IPs and SNAs both believed resistance to Project Avenger is largely a matter of misinformation about and lack of experience with the program. To some extent, IPs expect this problem to remedy itself when Project Avenger scales up and flight events become a regular part of instructor scheduling. In addition to the flight events, it may be helpful to hold brief training events to clarify the purposes of Project Avenger and expectations for SNA experience and performance early in the syllabus, as well as explain the syllabus and gradebooks. IPs found a single flight event with an Avenger SNA tended to turn people in favor of Project Avenger, so single-day training events may be sufficient to provide the necessary exposure to the program to overcome resistance. They would also help to calibrate instructors' expectations for SNAs so they can give appropriate levels of support during syllabus events.

With the increased workload for instructors on student interactions, flight preparations, briefing, and debriefing,

administrative work should be eased where possible. There appear to be two ways to ease administrative burden:

1. Dedicated Operations, Scheduling, and Student Control (STUCON) personnel should be designated to cover Project Avenger ground tasks and route paperwork.

2. The gradebooks should be exchanged for a user-friendly LMS, an action also recommended by CNATRA. Although making the LMS accessible remotely via tablets or smartphones may require rework of current cybersecurity policies, IPs emphasized it is a critical component of reducing workload by allowing them to update SNA grades between flights without returning to an office location. CNATRA reported they are currently in the process of finding a T-SHARP compatible LMS that can be accessed remotely, but do not have a timeline on delivery. An accessible LMS will also support SNAs by helping them track their completion of modules in ground training.

These two measures can help prevent instructor burnout, allow IPs to focus on training, and prevent the administrative task load from becoming a deterrent to IPs who might otherwise be interested in Primary training. CNATRA's report did not recommend designated personnel to cover ground tasks, but did recommend acquiring an automated scheduling system suited to detachment schedules, with the intention of integrating it into the LMS.

7.5.5. Additional Recommendations

Cybersecurity and Infrastructure

The focus groups stated the training bases are not configured to support Project Avenger-style training. This is imperative to address early as changes to infrastructure require years to complete. The largest issue is cybersecurity; current policies are restrictive enough to create a pronounced increase in workload and significant slowdown of information exchange. For example, discussion with IPs indicated that when the Oculus goggles required updates, they were taken off-site because onsite connectivity did not support simultaneous updates of multiple devices and security around WiFi access only supported a single device being updated at a time. Although specific recommendations for infrastructure and cybersecurity are outside

the scope of this evaluation and may be outside of CNATRA's purview to address, it is recommended these issues be addressed by the appropriate entities as soon as possible to prepare for a scaled-up Project Avenger and other NATN syllabi. CNATRA has reported they are currently working with Commander, Naval Air Forces (CNAF) to support Project Avenger's software needs within existing cybersecurity policies; however, this may only be a temporary fix as the program is expanded. The last aspect to infrastructure is ensuring a shared SNA-and-IP space in building plans to facilitate the detachment model.

Detachment Space

Several small recommendations focused on improving the detachment space:

- Continue and potentially expand both SNA and IP time in the detachment space. IPs observed spending time in the detachment space helped SNAs grasp concepts more quickly through additional exposure to content, ready access to materials and experts, and impromptu group study and discussions. IPs stated there were noticeable performance differences between the SNAs spending significant time in the spaces versus those who did not.

- Station at least one ITD in the detachment space. This would encourage active practice, group study, and IP-SNA coaching while in the detachment space.

- SNAs should return issued Oculus headsets after the first several weeks to be held in the detachment space. Headset use dropped off after the first several weeks, so storing in the detachment space would facilitate use as an additional study tool for SNAs while onsite, in a group, and with IPs available for discussion.

AOA

IPs stated an early intention of Project Avenger was to increase the amount of AoA approach training compared to the legacy syllabus, based on requests from the tailhook community. However, AoA approach training was not increased in the first class of Project Avenger. This is a need identified by the Fleet and should be addressed by future iterations.

MCG

Given the difficulty SNAs had with using the MCG, and the resulting tendency to use it infrequently, the MCG should be improved. In line with SNA suggestions, the MCG should be clarified to more clearly explain what is required in each stage and inconsistencies with the gradebook should be corrected by ensuring alignment between the MCG and the gradebook.

GK

IPs noted small decrements in GK at various points in the syllabus for Avenger students compared to their legacy counterparts. Although a continuous effort regardless of syllabus, some GK gained through legacy flight events was not gained as effectively in Project Avenger. This was addressed in the second and third classes by introducing minimum standards (PQS) in multiple sub-stages of training. The research team recommends the use of PQS for similar syllabi.

Technologies

Finally, a few smaller recommendations that could enhance the program are improvements to legacy technology capabilities or extending resources introduced in Project Avenger for practice:

- Per IP and SNA recommendations, work with the companies and contractors to improve the flight model accuracy (especially trim) and system reliability of the ITDs.

- Identify methods for improving simulated formation flight practice. These may include ITD upgrades to improve visual fidelity, UTD upgrades with XR headsets and support for connecting multiple UTDs, and/or updating connectivity capabilities of OFTs to enable formation flights.

- Extend the student capacity and available hours of the PilotEdge ATC capability and/or identify synthetic ATC options. CNATRA also recommended the PilotEdge extension in their report. Specifically, they recommend 0800-1600 availability on weekdays and making PilotEdge available to all Primary SNAs. Alternatively, artificial intelligent programs may be able to provide 24/7 ATC communication practice and should be explored.

- Explore adding a one- to two-hour brief introduction to paper charts. Currently, all publications used for Project Avenger training are electronic. Although the expectation is all charts will be electronic in the future, SNAs may encounter paper charts before that happens. IPs reported knowledge of paper charts would be beneficial to SNAs in future training.

8. Conclusions

Holistically, results from the first class of Project Avenger indicate it was successful. Although grades received (ERS) were lower on many specific events for Project Avenger SNAs compared to legacy counterparts, there are a multitude of factors affecting this, including meeting the expectations and designs of Avenger. These factors include:

- A goal of Avenger is to create a better generalized aviator rather than a T-6B technical expert. This led to a broader approach to introduction and practice of skillsets instead of focusing on one specific skill before moving on to another. This means Avenger SNAs have lower grades until the end of training when they have "mastered" all the necessary skills.

- Grading may not accurately reflect the relative difficulty of Project Avenger events.

- Difficulty weights (prescribed within Avenger or the research team's artificial weights) likely do not adequately account for SNAs challenging themselves. Avenger-prescribed weights may benefit from being required for some or all events.

- Instructors' expectations may have been misaligned when grading Avenger SNAs.

- It was difficult to compare events between different training methodologies (Avenger vs legacy), especially for the Mission Stage.

Looking beyond grades, IPs and SNAs believed Project Avenger successfully developed a generalized aviator with strong critical thinking skills, who could fly complex missions and

respond appropriately to contingencies. Their belief that the advantages of Project Avenger will last long after Primary training requires further performance evaluation, but this report provides initial evidence that individually-tailored training based on skill progression, leveraging a detachment-style culture, and access to virtual study materials are effective for flight training. This was true in the first class of Project Avenger, in spite of somewhat disorganized Instrument training and a slight decrement in GK. Changes already implemented during the writing of this report are expected to mitigate or eliminate these two disadvantages, increasing the effectiveness of the next iteration of Project Avenger.

The first class of Project Avenger was also more efficient than legacy training. Project Avenger SNAs reached Safe for Solo and were prepared for cross-country flight in fewer flights than legacy SNAs, and the first class completed the syllabus more quickly than legacy SNAs. Additionally, expectations are that SNAs will reach proficiency in fewer flights in the future, there will be more Formation-qualified instructors after changes to the FITU, and Project Avenger will screen out poor pilots earlier than the legacy syllabus. Project Avenger therefore appears to be an effective means of producing more effective pilots more efficiently, helping address the Navy's pilot shortage in a cost-effective manner.

Data have not yet been made available on the performance of Project Avenger graduates beyond Primary training, leaving open the question of whether graduates perform better than legacy program graduates. Avenger SNAs will need to be tracked and monitored to see what long-term effects this new methodology has on training outcomes and how long advantages can be seen. Answering these questions will be an important component of determining Project Avenger's overall effectiveness. Currently, however, it is clear Project Avenger is a viable alternative to legacy Primary training that can help address training efficiency issues while maintaining strong performance.

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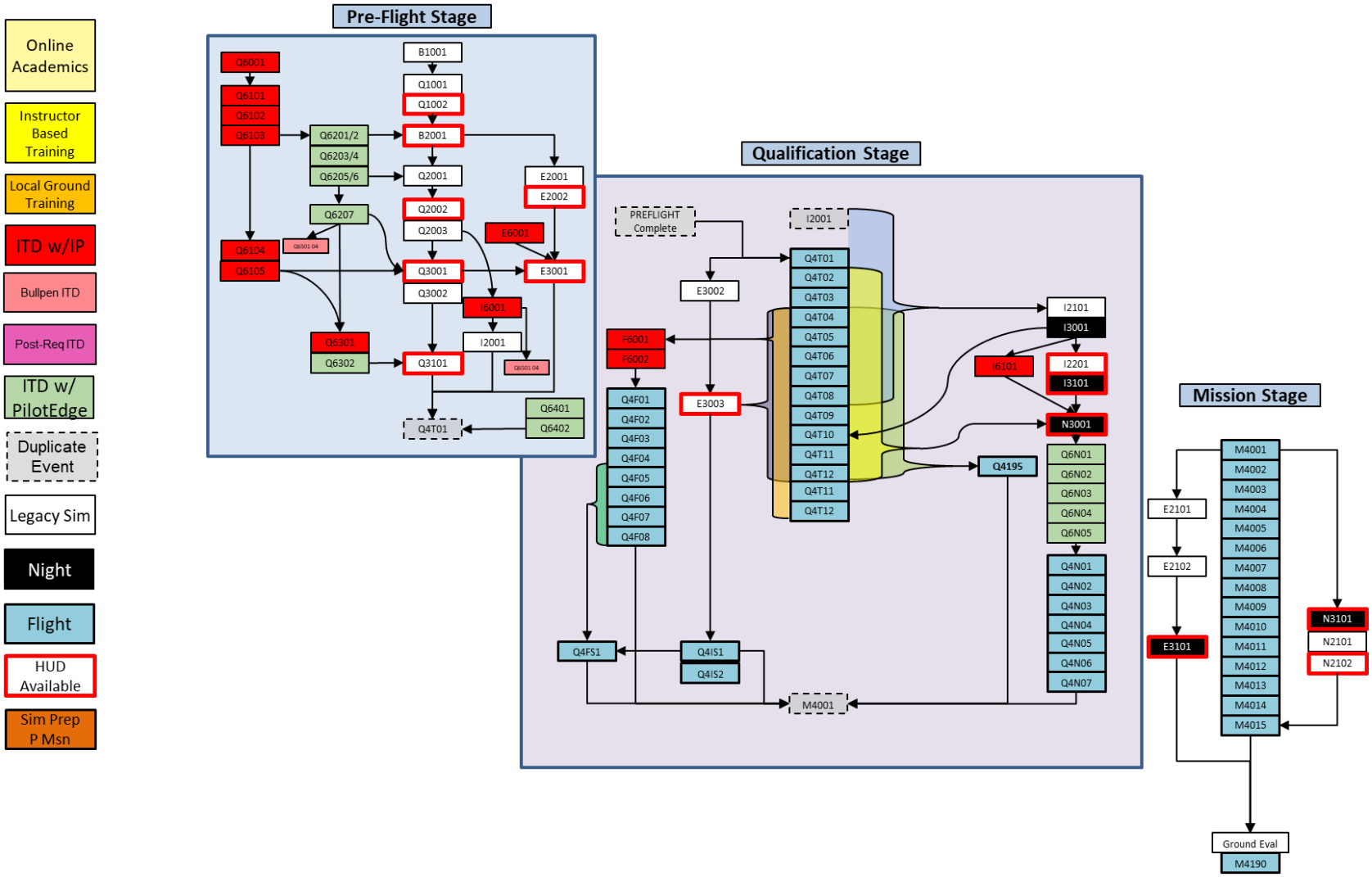
10. Appendices

10.1. Appendix 1: Project Avenger Syllabus Flow



10.2. Appendix 2: Student Feedback Questionnaire

1. What stage of Avenger have you most recently completed?

   - ○ PREFLIGHT
   - ○ QUALIFICATION
   - ○ MISSION

2. If you are leaving the Avenger Program, please tell us why (select all that apply):

   - ☐ N/A- continuing in or completed the Avenger Program
   - ☐ Workload is too intense
   - ☐ Schedule is too compressed
   - ☐ Content too difficult to understand
   - ☐ Instructional strategies do not fit my learning style
   - ☐ Not enough classroom content
   - ☐ Not enough Virtual Reality events
   - ☐ Not enough Live Flight events
   - ☐ Did not meet Course Training Standards
   - ☐ Other (please specify) _____

Rating of Course Materials

Project Avenger introduces several different types of course materials. Please rate them across the dimensions provided.

3. Please rate the **ACCESSIBILITY** of:

	Never Accessible		Somewhat accessible	Somewhat inaccessible		Always Accessible	N/A
Master Curriculum Guide	○	○	○	○	○	○	○
Technical Manuals (NATOPS, FTI, Course Rules, etc.)	○	○	○	○	○	○	○
Avenger Modules	○	○	○	○	○	○	○

360-degree Videos with Oculus Goggles	○	○	○	○	○	○	○
360-degree Videos via YouTube (personal device/ tablet)	○	○	○	○	○	○	○
VR Trainer with PilotEdge	○	○	○	○	○	○	○
VR Trainer with an Instructor (in-person)	○	○	○	○	○	○	○
VR Training Solo Practice (no PilotEdge)	○	○	○	○	○	○	○
CloudAhoy	○	○	○	○	○	○	○
ForeFlight	○	○	○	○	○	○	○
General iPad Usage	○	○	○	○	○	○	○
Google Drive (24/7 Content Availability)	○	○	○	○	○	○	○
Detachment IP and Stash Support	○	○	○	○	○	○	○

4. Please rate how **FREQUENTLY** you utilized:

	Never		Sometimes, but not often	More often than not		All the time	N/A
Master Curriculum Guide	○	○	○	○	○	○	○
Technical Manuals (NATOPS, FTI, Course Rules, etc.)	○	○	○	○	○	○	○
Avenger Modules	○	○	○	○	○	○	○
360-degree Videos with Oculus Goggles	○	○	○	○	○	○	○
360-degree Videos via YouTube (personal device/ tablet)	○	○	○	○	○	○	○
VR Trainer with PilotEdge	○	○	○	○	○	○	○
VR Trainer with an Instructor (in-person)	○	○	○	○	○	○	○
VR Training Solo Practice	○	○	○	○	○	○	○

(no PilotEdge)							
CloudAhoy	○	○	○	○	○	○	○
ForeFlight	○	○	○	○	○	○	○
General iPad Usage	○	○	○	○	○	○	○
Google Drive (24/7 Content Availability)	○	○	○	○	○	○	○
Detachment IP and Stash Support	○	○	○	○	○	○	○

5. Please rate how **EASY TO USE** the following materials were:

	Extremely Difficult		Somewhat Difficult	Somewhat Easy		Extremely Easy	N/A
Master Curriculum Guide	○	○	○	○	○	○	○
Technical Manuals (NATOPS, FTI, Course Rules, etc.)	○	○	○	○	○	○	○
Avenger Modules	○	○	○	○	○	○	○
360-degree Videos with Oculus Goggles	○	○	○	○	○	○	○
360-degree Videos via YouTube (personal device/ tablet)	○	○	○	○	○	○	○
VR Trainer with PilotEdge	○	○	○	○	○	○	○
VR Trainer with an Instructor (in-person)	○	○	○	○	○	○	○
VR Training Solo Practice (no PilotEdge)	○	○	○	○	○	○	○
CloudAhoy	○	○	○	○	○	○	○
ForeFlight	○	○	○	○	○	○	○
General iPad Usage	○	○	○	○	○	○	○
Google Drive (24/7 Content Availability)	○	○	○	○	○	○	○
Detachment IP and Stash Support	○	○	○	○	○	○	○

6. Please rate how **BENEFICIAL TO YOUR LEARNING** the following materials were:

	Useless		Some use, but not much	Somewhat beneficial		Extremely Beneficial	N/A
Master Curriculum Guide	○	○	○	○	○	○	○
Technical Manuals (NATOPS, FTI, Course Rules, etc.)	○	○	○	○	○	○	○
Avenger Modules	○	○	○	○	○	○	○
360-degree Videos with Oculus Goggles	○	○	○	○	○	○	○
360-degree Videos via YouTube (personal device/ tablet)	○	○	○	○	○	○	○
VR Trainer with PilotEdge	○	○	○	○	○	○	○
VR Trainer with an Instructor (in-person)	○	○	○	○	○	○	○
VR Training Solo Practice (no PilotEdge)	○	○	○	○	○	○	○
CloudAhoy	○	○	○	○	○	○	○
ForeFlight	○	○	○	○	○	○	○
General iPad Usage	○	○	○	○	○	○	○
Google Drive (24/7 Content Availability)	○	○	○	○	○	○	○
Detachment IP and Stash Support	○	○	○	○	○	○	○

7. Please rate how **RELEVANT TO YOUR TRAINING** the following materials were at this last stage:

	Not at all relevant		Some relevance, but not much	Somewhat relevant		Extremely Relevant	N/A
Master Curriculum Guide	○	○	○	○	○	○	○
Technical Manuals (NATOPS, FTI, Course Rules, etc.)	○	○	○	○	○	○	○
Avenger Modules	○	○	○	○	○	○	○
360-degree Videos with Oculus Goggles	○	○	○	○	○	○	○

360-degree Videos via YouTube (personal device/ tablet)	○	○	○	○	○	○	○
VR Trainer with PilotEdge	○	○	○	○	○	○	○
VR Trainer with an Instructor (in-person)	○	○	○	○	○	○	○
VR Training Solo Practice (no PilotEdge)	○	○	○	○	○	○	○
CloudAhoy	○	○	○	○	○	○	○
ForeFlight	○	○	○	○	○	○	○
General iPad Usage	○	○	○	○	○	○	○
Google Drive (24/7 Content Availability)	○	○	○	○	○	○	○
Detachment IP and Stash Support	○	○	○	○	○	○	○

8. Please rate the **QUALITY OF CONTENT** provided by the following materials:

	Extremely low quality		Somewhat low quality	Somewhat high quality		Extremely high quality	N/A
Master Curriculum Guide	○	○	○	○	○	○	○
Technical Manuals (NATOPS, FTI, Course Rules, etc.)	○	○	○	○	○	○	○
Avenger Modules	○	○	○	○	○	○	○
360-degree Videos with Oculus Goggles	○	○	○	○	○	○	○
360-degree Videos via YouTube (personal device/ tablet)	○	○	○	○	○	○	○
VR Trainer with PilotEdge	○	○	○	○	○	○	○
VR Trainer with an Instructor (in-person)	○	○	○	○	○	○	○
VR Training Solo Practice (no PilotEdge)	○	○	○	○	○	○	○
CloudAhoy	○	○	○	○	○	○	○

ForeFlight	○	○	○	○	○	○	○
General iPad Usage	○	○	○	○	○	○	○
Google Drive (24/7 Content Availability)	○	○	○	○	○	○	○
Detachment IP and Stash Support	○	○	○	○	○	○	○

9. Please describe which of the course materials rated was of **greatest benefit** during this stage of training and why:

_____
_____
_____

10. Please describe which of the course materials used and rated was **least beneficial** during this stage of training and why:

_____
_____
_____

11. What is one thing you would change about the course materials to improve the benefit to training?

_____
_____
_____

Rating of Content & Delivery

Project Avenger utilizes a lot of new content and different methods for delivery. Please rate the content and its delivery across the following dimensions.

12. Please rate the **EFFECTIVENESS OF DELIVERY METHOD** for the content using the following methodology (i.e., the method was appropriate for the content):

	Not at all effective		Somewhat ineffective	Somewhat effective		Extremely effective	N/A
At-home Coursework	○	○	○	○	○	○	○
Avenger Modules (2D and 360 videos)	○	○	○	○	○	○	○
In-person Lectures	○	○	○	○	○	○	○

Detachment IP and Stash Support	○	○	○	○	○	○	○
Solo VR and Simulator Practice (no IP)	○	○	○	○	○	○	○
VR events with an IP	○	○	○	○	○	○	○
PilotEdge	○	○	○	○	○	○	○
UTD	○	○	○	○	○	○	○
IFT	○	○	○	○	○	○	○
Augmented Reality (UTD with VR headset)	○	○	○	○	○	○	○
OFT	○	○	○	○	○	○	○
Qualification Flight Events	○	○	○	○	○	○	○
Mission Flight Events	○	○	○	○	○	○	○

13. Please rate your **ENGAGEMENT WITH THE MATERIAL** using the following methodology:

	Not at all engaged		Somewhat disengaged	Somewhat engaged		Extremely engaged	N/A
At-home Coursework	○	○	○	○	○	○	○
Avenger Modules (2D and 360 videos)	○	○	○	○	○	○	○
In-person Lectures	○	○	○	○	○	○	○
Detachment IP and Stash Support	○	○	○	○	○	○	○
Solo VR and Simulator Practice (no IP)	○	○	○	○	○	○	○
VR events with an IP	○	○	○	○	○	○	○
PilotEdge	○	○	○	○	○	○	○
UTD	○	○	○	○	○	○	○
IFT	○	○	○	○	○	○	○
Augmented Reality (UTD with VR headset)	○	○	○	○	○	○	○
OFT	○	○	○	○	○	○	○
Qualification Flight Events	○	○	○	○	○	○	○
Mission Flight Events	○	○	○	○	○	○	○

14. Please rate the **QUALITY OF METHODOLOGY:**

	Extremely low quality		Somewhat low quality	Somewhat high quality		Extremely high quality	N/A
At-home Coursework	○	○	○	○	○	○	○
Avenger Modules (2D and 360 videos)	○	○	○	○	○	○	○
In-person Lectures	○	○	○	○	○	○	○
Detachment IP and Stash Support	○	○	○	○	○	○	○
Solo VR and Simulator Practice (no IP)	○	○	○	○	○	○	○
VR events with an IP	○	○	○	○	○	○	○
PilotEdge	○	○	○	○	○	○	○
UTD	○	○	○	○	○	○	○
IFT	○	○	○	○	○	○	○
Augmented Reality (UTD with VR headset)	○	○	○	○	○	○	○
OFT	○	○	○	○	○	○	○
Qualification Flight Events	○	○	○	○	○	○	○
Mission Flight Events	○	○	○	○	○	○	○

15. Please rate how **UNDERSTANDABLE** the material when delivered by this methodology:

	Not at all understandable		Somewhat hard to understand	Somewhat understandable		Extremely understandable	N/A
At-home Coursework	○	○	○	○	○	○	○
Avenger Modules (2D and 360 videos)	○	○	○	○	○	○	○
In-person Lectures	○	○	○	○	○	○	○
Detachment IP and Stash Support	○	○	○	○	○	○	○
Solo VR and Simulator Practice (no IP)	○	○	○	○	○	○	○
VR events with an IP	○	○	○	○	○	○	○
PilotEdge	○	○	○	○	○	○	○
UTD	○	○	○	○	○	○	○
IFT	○	○	○	○	○	○	○
Augmented Reality (UTD with VR headset)	○	○	○	○	○	○	○

OFT	○	○	○	○	○	○	○
Qualification Flight Events	○	○	○	○	○	○	○
Mission Flight Events	○	○	○	○	○	○	○

16. Please rate how **BENEFICIAL TO LEARNING** the material was when delivered by this methodology:

	Useless		Some use, but not much	Somewhat beneficial		Extremely beneficial	N/A
At-home Coursework	○	○	○	○	○	○	○
Avenger Modules (2D and 360 videos)	○	○	○	○	○	○	○
In-person Lectures	○	○	○	○	○	○	○
Detachment IP and Stash Support	○	○	○	○	○	○	○
Solo VR and Simulator Practice (no IP)	○	○	○	○	○	○	○
VR events with an IP	○	○	○	○	○	○	○
PilotEdge	○	○	○	○	○	○	○
UTD	○	○	○	○	○	○	○
IFT	○	○	○	○	○	○	○
Augmented Reality (UTD with VR headset)	○	○	○	○	○	○	○
OFT	○	○	○	○	○	○	○
Qualification Flight Events	○	○	○	○	○	○	○
Mission Flight Events	○	○	○	○	○	○	○

17. Please rate the **QUALITY OF CONTENT** delivered by this methodology:

	Extremely low quality		Somewhat low quality	Somewhat high quality		Extremely high quality	N/A
At-home Coursework	○	○	○	○	○	○	○
Avenger Modules (2D and 360 videos)	○	○	○	○	○	○	○
In-person Lectures	○	○	○	○	○	○	○
Detachment IP and Stash Support	○	○	○	○	○	○	○
Solo VR and Simulator	○	○	○	○	○	○	○

Practice (no IP)							
VR events with an IP	○	○	○	○	○	○	○
PilotEdge	○	○	○	○	○	○	○
UTD	○	○	○	○	○	○	○
IFT	○	○	○	○	○	○	○
Augmented Reality (UTD with VR headset)	○	○	○	○	○	○	○
OFT	○	○	○	○	○	○	○
Qualification Flight Events	○	○	○	○	○	○	○
Mission Flight Events	○	○	○	○	○	○	○

18. Please rate your **UNDERSTANDING OF EXPECTATIONS** for learning for the material delivered by:

	No understanding		Somewhat not clear	Somewhat understandable		Extremely clear and understandable	N/A
At-home Coursework	○	○	○	○	○	○	○
Avenger Modules (2D and 360 videos)	○	○	○	○	○	○	○
In-person Lectures	○	○	○	○	○	○	○
Detachment IP and Stash Support	○	○	○	○	○	○	○
Solo VR and Simulator Practice (no IP)	○	○	○	○	○	○	○
VR events with an IP	○	○	○	○	○	○	○
PilotEdge	○	○	○	○	○	○	○
UTD	○	○	○	○	○	○	○
IFT	○	○	○	○	○	○	○
Augmented Reality (UTD with VR headset)	○	○	○	○	○	○	○
OFT	○	○	○	○	○	○	○
Qualification Flight Events	○	○	○	○	○	○	○
Mission Flight Events	○	○	○	○	○	○	○

19. Please describe which of the course delivery methods rated was of **greatest benefit** during this stage of training and why:

_____
_____
_____

20. Please describe which of the course delivery methods been through and rated was **least beneficial** during this stage of training and why:

_____
_____
_____

21. What is one thing you would change about the content and/or delivery methods to improve the benefit to training?

_____
_____
_____

SIM & Flight Instructors

Please rate your SIM and Flight instructors across the following characteristics:

22. Overall, to what extend did the SIM instructors:

	Not at all		To some extent, but not much	Somewhat of an extent		To a great extent	N/A
Grading according to Course Training Standards (CTS)	○	○	○	○	○	○	○
Knowledge of the aircraft and its systems	○	○	○	○	○	○	○
Adherence to up-to-date checklists, SOPs, references (FTI, NATOPS, Course Rules, etc.), and safety procedures	○	○	○	○	○	○	○
Explains new concepts in clear and relatable terms based on	○	○	○	○	○	○	○

student's prior knowledge							
Sets clear expectations of the student's performance and knowledge/ understanding	○	○	○	○	○	○	○
Provides clear guidance on how to learn from and correct mistakes	○	○	○	○	○	○	○
Professionalism, military bearing, and enthusiasm for student learning	○	○	○	○	○	○	○
Encouraged student to take on new challenges	○	○	○	○	○	○	○
Value and effectiveness of brief	○	○	○	○	○	○	○
Value and effectiveness of debrief	○	○	○	○	○	○	○

23. Overall, to what extent did the **Flight** instructors:

	Not at all		To some extent, but not much	Somewhat of an extent		To a great extent	N/A
Grading according to Course Training Standards (CTS)	○	○	○	○	○	○	○
Knowledge of the aircraft and its systems	○	○	○	○	○	○	○
Adherence to up-to-date checklists, SOPs, references (FTI, NATOPS, Course Rules, etc.), and safety procedures	○	○	○	○	○	○	○
Explains new concepts in clear and relatable terms based on student's prior knowledge	○	○	○	○	○	○	○
Sets clear expectations of the student's performance and knowledge/ understanding	○	○	○	○	○	○	○
Provides clear guidance on how to learn from and correct mistakes	○	○	○	○	○	○	○
Professionalism, military	○	○	○	○	○	○	○

bearing, and enthusiasm for student learning							
Encouraged student to take on new challenges	○	○	○	○	○	○	○
Value and effectiveness of brief	○	○	○	○	○	○	○
Value and effectiveness of debrief	○	○	○	○	○	○	○

24. What made SIM events most effective for learning?

_____
_____
_____

25. What made SIM events most ineffective for learning?

_____
_____
_____

26. What is one thing SIM instructors could do to improve training?

_____
_____
_____

27. What made Flight events most effective for learning?

_____
_____
_____

28. What made Flight events most ineffective for learning?

_____
_____
_____

29. What is one thing Flight instructors could do to improve training?

_____
_____
_____

Summary Feedback

30. What, if anything, can Project Avenger do to better train or prepare students for success during training?

_____
_____
_____

31. Do you have any additional comments, criticisms, or suggestions for Project Avenger based on your experience to date in training that have not been covered?

_____
_____
_____

32. Would you recommend Project Avenger training to other students (over legacy training)?

- O Yes
- O No
- O Other (please specify)

  _____

10.3. Appendix 3: Focus Group Questions

1. During your involvement with or observation of the Project Avenger program:
    a. What do you think the benefits are compared to legacy training?
    b. What do you think the limitations are compared to legacy training?
    c. What legacy training limitations did Project Avenger NOT address?
2. What effect did the Mission Stage have on students' pilot skills?
    a. What changes, if any, should be implemented in the Mission Stage to enhance student performance outcomes?
3. What changes, if any, should be implemented in future iterations of Project Avenger as a whole to enhance student performance outcomes?
4. Does Project Avenger include enough resources (e.g., time, guidebooks, VR/aircraft availability) for the following to effectively train a pilot? Are there any areas where more or fewer resources should be allocated?:
    a. Classroom
    b. Simulators
    c. Live flight
5. Are there any areas of the syllabus in which students should receive more instructor support?
6. Are there any differences in specific student habits or tendencies between Project Avenger students and legacy students?
    a. What are the differences?
    b. Are these differences good for Project Avenger or bad? Why?

7. Are there any impacts on student performance in the aircraft from Project Avenger?

    a. What are the positive or negative impacts?

    b. Do you think these performance differences (if any) will carry forward into their performance beyond Primary training?

8. With Project Avenger students, are you able to focus on instructing different tasks/skills during SIM events compared to legacy students (e.g., focusing more in-depth on techniques or situations)?

9. With Project Avenger students, are you able to focus on instructing different tasks/skills during live training flights compared to legacy students (e.g., focusing more in-depth on techniques or situations)?

10. Do you think that Project Avenger uses the T-6B Virtual Reality trainers (trainers with desktop computer and a Virtual Reality headset) to their best advantage?

    a. What changes, if any, should be made to how Project Avenger uses the Virtual Reality trainers?

11. What are your thoughts on the timeline of Project Avenger? What changes would you make to the timeline throughout the syllabus? Please explain your answer.

12. What do instructors think about switching to Project Avenger-style training?

13. What is the workload for instructors on Project Avenger? How does it compare to the workload on legacy training?

    a. What changes, if any, should be made to the workload?

14. Were instructors sufficiently prepared for Project Avenger?

    a. If not, what could help them get better prepared?

15. Assuming Project Avenger will have enough resources for all future students:

a. What types of students (if any) **SHOULD** go through Project Avenger? Why?

b. What types of students (if any) **SHOULD <u>NOT</u>** go through Project Avenger? Why?

16. Do you have any other feedback or recommendations on Project Avenger?

10.4. Appendix 4: Summarized Responses to Student Feedback Questionnaire

Note: In this appendix, abbreviations and acronyms are not spelled out to conserve space in the tables. Appendix 5 contains a list of abbreviations and acronyms spelled out.

10.4.1. Course Materials

Table 10. Accessibility

Course Materials	Pre-Flight Stage (17 respondents)			Qualification Stage (6 respondents)			*Mission Stage (14 respondents)*		
	Mdn	*IQR*	*N/A*	*Mdn*	*IQR*	*N/A*	*Mdn*	*IQR*	*N/A*
Master Curriculum Guide	6	3	2	6	0	0	6	1.25	2
Technical Manuals (NATOPS, FTI, Course Rules, etc.)	6	0	1	6	0	0	6	0	2
Avenger Modules	6	0	1	6	0	0	6	1.5	2
360-degree Videos with Oculus Goggles	6	1.25	1	6	1.5	0	5	1.25	2
360-degree Videos via YouTube (personal device/tablet)	6	1.5	1	5	2.75	0	5.5	1.25	2
VR Trainer with PilotEdge	6	2	1	5	2.25	0	5	2	2
VR Trainer with an Instructor (in-person)	3	2.25	1	3.5	1.75	0	4.5	1	2
VR Training Solo Practice (no PilotEdge)	6	1	1	6	0	0	6	1.25	2
CloudAhoy	6	2.75	3	6	0	0	6	1.5	3
ForeFlight	6	0	2	6	0	0	6	0	2
General iPad Usage	6	0	2	6	0	0	6	0	2
Google Drive (24/7 Content Availability)	6	0	1	6	0	0	6	0	2
Detachment IP and Stash Support	6	0	1	6	1	1	6	1.25	2

Note. Mdn = Median rating on a 0-5 scale, IQR = interquartile range, N/A = number of "N/A" or missing responses. Median and interquartile range are employed instead of mean and standard deviation to avoid assuming equal intervals between scale responses.

Table 11. Frequency of use

Course Materials	Pre-Flight Stage (17 respondents)			Qualification Stage (6 respondents)			*Mission Stage (14 respondents)*		
	Mdn	*IQR*	*N/A*	*Mdn*	*IQR*	*N/A*	*Mdn*	*IQR*	*N/A*
Master Curriculum Guide	3	0.5	1	3	0.75	0	3	1	1
Technical Manuals (NATOPS, FTI, Course Rules, etc.)	6	0	1	6	1.5	0	6	0	1
Avenger Modules	4	1	1	3	0.75	0	4	2	1
360-degree Videos with Oculus Goggles	3	0	1	2.5	1	0	3	1.25	2
360-degree Videos via YouTube (personal device/tablet)	3	0.5	1	3	0.75	0	3.5	1.25	2
VR Trainer with PilotEdge	4	2	1	3.5	1.75	0	4	1	1
VR Trainer with an Instructor (in-person)	5.5	2	1	4	0.75	0	3	1	1
VR Training Solo Practice (no PilotEdge)	4	1.25	1	4.5	2.5	0	5	2	1
CloudAhoy	3	1	3	3	3	0	3.5	1.25	2
ForeFlight	6	0	2	6	0	0	6	0	1
General iPad Usage	6	0	2	6	0	0	6	0	1
Google Drive (24/7 Content Availability)	6	0	1	6	0	0	6	0	1
Detachment IP and Stash Support	5.5	2	1	6	2	1	5	2	2

Note. Mdn = Median rating on a 0-5 scale, IQR = interquartile range, N/A = number of "N/A" or missing responses. Median and interquartile range are employed instead of mean and standard deviation to avoid assuming equal intervals between scale responses.

Table 12. Ease of use

Course Materials	Pre-Flight Stage (17 respondents)			Qualification Stage (6 respondents)			*Mission Stage (14 respondents)*		
	Mdn	*IQR*	*N/A*	*Mdn*	*IQR*	*N/A*	*Mdn*	*IQR*	*N/A*
Master Curriculum Guide	3	1	1	3	0	1	4	1	1
Technical Manuals (NATOPS, FTI,	6	1	1	5.5	1.75	0	6	1	1

Course Materials	Pre-Flight Stage (17 respondents)			Qualification Stage (6 respondents)			*Mission Stage (14 respondents)*		
	Mdn	*IQR*	*N/A*	*Mdn*	*IQR*	*N/A*	*Mdn*	*IQR*	*N/A*
Course Rules, etc.)									
Avenger Modules	5.5	2	1	5.5	1.75	0	5	2	1
360-degree Videos with Oculus Goggles	6	2	1	4.5	1.75	0	4	1	1
360-degree Videos via YouTube (personal device/tablet)	6	2.5	2	4.5	1.75	0	4	1	1
VR Trainer with PilotEdge	4	1.25	1	5	1.5	0	5	2	1
VR Trainer with an Instructor (in-person)	4.5	2	1	5.5	1.75	0	4	1	1
VR Training Solo Practice (no PilotEdge)	5	2	1	6	0.75	0	6	1	1
CloudAhoy	4	1.75	3	5.5	1.75	0	5	2.5	3
ForeFlight	6	0.5	2	6	0	0	6	0	1
General iPad Usage	6	0	2	6	0	0	6	0	2
Google Drive (24/7 Content Availability)	6	0	2	6	0	0	6	0	2
Detachment IP and Stash Support	6	0	2	5.5	1.75	0	6	0.5	2

Note. Mdn = Median rating on a 0-5 scale, IQR = interquartile range, N/A = number of "N/A" or missing responses. Median and interquartile range are employed instead of mean and standard deviation to avoid assuming equal intervals between scale responses.

Table 13. Course material's benefit to learning

Course Materials	Pre-Flight Stage (17 respondents)			Qualification Stage (6 respondents)			*Mission Stage (14 respondents)*		
	Mdn	*IQR*	*N/A*	*Mdn*	*IQR*	*N/A*	*Mdn*	*IQR*	*N/A*
Master Curriculum Guide	3	1	2	3.5	1	0	4	2	1
Technical Manuals (NATOPS, FTI, Course Rules, etc.)	6	0	1	6	1.5	0	6	0	1
Avenger Modules	5	2	1	4	2.25	0	5	2	1
360-degree Videos with Oculus Goggles	4	1	1	3.5	1	0	4	3	1
360-degree Videos via	4	2	2	3.5	1	0	4	1	1

Course Materials	Pre-Flight Stage (17 respondents)			Qualification Stage (6 respondents)			*Mission Stage (14 respondents)*		
	Mdn	*IQR*	*N/A*	*Mdn*	*IQR*	*N/A*	*Mdn*	*IQR*	*N/A*
YouTube (personal device/tablet)									
VR Trainer with PilotEdge	6	0	1	6	0	0	6	0	1
VR Trainer with an Instructor (in-person)	6	0	1	6	1.5	0	6	0	1
VR Training Solo Practice (no PilotEdge)	5.5	1.25	1	6	0	0	6	1.25	2
CloudAhoy	4	1.75	3	3.5	2.5	0	5	2	3
ForeFlight	6	0	2	6	0	0	6	0	1
General iPad Usage	6	0	2	6	0	0	6	0	1
Google Drive (24/7 Content Availability)	6	0	2	6	0	0	6	0	1
Detachment IP and Stash Support	6	0	2	6	1.5	0	6	0	2

Note. Mdn = Median rating on a 0-5 scale, IQR = interquartile range, N/A = number of "N/A" or missing responses. Median and interquartile range are employed instead of mean and standard deviation to avoid assuming equal intervals between scale responses.

Table 14. Relevance to training

Course Materials	Pre-Flight Stage (17 respondents)			Qualification Stage (6 respondents)			*Mission Stage (14 respondents)*		
	Mdn	*IQR*	*N/A*	*Mdn*	*IQR*	*N/A*	*Mdn*	*IQR*	*N/A*
Master Curriculum Guide	3	1	1	3.5	1.75	0	4	1	1
Technical Manuals (NATOPS, FTI, Course Rules, etc.)	6	0	1	5.5	1.75	0	6	0	1
Avenger Modules	5.5	2	1	4.5	1	0	5	1	1
360-degree Videos with Oculus Goggles	4	1	1	4	0.75	0	4	1	1
360-degree Videos via YouTube (personal device/tablet)	4	1	2	4	0.75	0	4	2	1
VR Trainer with PilotEdge	6	0	1	6	1.5	0	6	1	1
VR Trainer with an Instructor (in-person)	6	0	1	6	1.5	0	6	2	1

Course Materials	Pre-Flight Stage (17 respondents)			Qualification Stage (6 respondents)			*Mission Stage (14 respondents)*		
	Mdn	*IQR*	*N/A*	*Mdn*	*IQR*	*N/A*	*Mdn*	*IQR*	*N/A*
VR Training Solo Practice (no PilotEdge)	6	1.25	1	6	0	0	6	2	1
CloudAhoy	4	1.75	3	4	2.25	0	3	2	1
ForeFlight	6	0	2	6	0	0	6	0	1
General iPad Usage	6	0	2	6	0	0	6	0	1
Google Drive (24/7 Content Availability)	6	0	2	6	0	0	6	0	1
Detachment IP and Stash Support	6	0	2	6	1.5	0	6	0	1

Note. Mdn = Median rating on a 0-5 scale, IQR = interquartile range, N/A = number of "N/A" or missing responses. Median and interquartile range are employed instead of mean and standard deviation to avoid assuming equal intervals between scale responses.

Table 15. Course material's quality of content

Course Materials	Pre-Flight Stage (17 respondents)			Qualification Stage (6 respondents)			*Mission Stage (14 respondents)*		
	Mdn	*IQR*	*N/A*	*Mdn*	*IQR*	*N/A*	*Mdn*	*IQR*	*N/A*
Master Curriculum Guide	4	0	4	5	2.75	0	4	1	3
Technical Manuals (NATOPS, FTI, Course Rules, etc.)	6	1	2	6	1.5	0	5	2	2
Avenger Modules	4	1.5	2	5.5	1.75	0	5	1.25	2
360-degree Videos with Oculus Goggles	5	2	3	4	0.75	0	5	1	2
360-degree Videos via YouTube (personal device/tablet)	5	1.5	2	4	0	0	5	1	2
VR Trainer with PilotEdge	6	1	2	6	0	0	5.5	2	2
VR Trainer with an Instructor (in-person)	6	0	2	6	1.5	0	6	1.25	2
VR Training Solo Practice (no PilotEdge)	5	2	2	6	1.5	0	5	1.25	2
CloudAhoy	4	1.5	6	6	1	1	5	2	3
ForeFlight	6	0.75	3	6	0	0	6	0	2
General iPad Usage	6	0.75	3	6	0	0	6	0	2

Course Materials	Pre-Flight Stage (17 respondents)			Qualification Stage (6 respondents)			*Mission Stage (14 respondents)*		
	Mdn	*IQR*	*N/A*	*Mdn*	*IQR*	*N/A*	*Mdn*	*IQR*	*N/A*
Google Drive (24/7 Content Availability)	6	0	3	6	0	0	6	0	2
Detachment IP and Stash Support	6	0	3	5	2	0	6	0	2

Note. Mdn = Median rating on a 0-5 scale, IQR = interquartile range, N/A = number of "N/A" or missing responses. Median and interquartile range are employed instead of mean and standard deviation to avoid assuming equal intervals between scale responses.

Table 16. Most beneficial course material

	Pre-Flight Stage (17 respondents)		Qualification Stage (6 respondents)		*Mission Stage (14 respondents)*	
Course Materials	Count	Reasons	Count	Reasons	Count	Reasons
Master Curriculum Guide	0		0		0	
Technical Manuals Overall	0		0		0	
NATOPS	1		0		1	Along with the Avenger forms supplement and FTI, gave the most detail on how to plan maneuvers (n=1)
FTI	1		2		1	Along with the Avenger forms supplement and NATOPS, gave the most detail on how to plan maneuvers (n=1)
Course Rules	0		0		0	
Technical Manuals (Other)	0		0		0	
Avenger Modules	1		1		0	
360-degree Videos Overall	0		0		0	
360-degree Videos with Oculus Goggles	1	Good for initial Course Rules learning	0		0	
360-degree Videos via YouTube	0		0		0	
VR Trainers Overall	7	Good for learning Course Rules (n=4), Communications (n=4), maneuvers (n=2), high work (n=1), PEL (n=1), and sight picture for FTI content (n=1)	3	Practice on free time (n=1); opportunity for skill practice (n=1); always available, unlike traditional SIMs (n=1)	4	Most useful early on although less useful in mid-to-late syllabus (n=1), realism (n=1), good for chair flying and flight planning (n=1)

Course Materials	Pre-Flight Stage (17 respondents) Count	Reasons	Qualification Stage (6 respondents) Count	Reasons	*Mission Stage (14 respondents)* Count	Reasons
VR Trainer with PilotEdge	3	Good for learning communications (n=1)	1		1	
VR Trainer with an Instructor (in-person)	1		0		1	Pass/fail format made SNA comfortable with asking about concepts they did not fully understand (n=1)
VR Training Solo Practice	0		0		0	
CloudAhoy	0		0		0	
ForeFlight	1		1	Excellent flight planning (n=1)	3	Made it easier to do flight planning for complicated profiles (n=1); helped with on-the-go flight planning adjustments necessitated by unpredictability in the Mission Stage (n=1)
General iPad Usage	4	Good for access to content (n=2), makes publications more portable (n=1), facilitates learning (n=1)	1	Access to content (n=1)	3	Useful for chairflying and flight planning (n=1), gave access to content (n=1)
Google Drive	0		0		0	
Detachment IP and Stash Support	0		0		0	
Detachment IP Support	2	Good for answering questions (n=1) and explaining content (n=1)	0		6	IPs were available to answer questions and practice scenarios (n=1); helped with on-the-go flight planning adjustments necessitated by unpredictability in the Mission Stage (n=1)
Detachment Stash Support	0		0		0	

Table 17. Least beneficial course material

	Pre-Flight Stage (17 respondents)		Qualification Stage (6 respondents)		*Mission Stage (14 respondents)*	
Course Materials	Count	Reasons	Count	Reasons	Count	Reasons
Master Curriculum Guide	6	Difficult to navigate (n=2), difficult to understand (n=1), never used it (n=1), redundant with other documents that explain training requirements (n=2 ,with one stating that other documents are easier to use)	2	Confusing and SSRs were changed (n=1)	5	Only consulted MCG for SSRs (n=1); unclear on graded items and SSRs (n=1); inconsistent on SSRs (n=1); difficult to navigate (n=1); inconsistent with gradebook (n=1); distracting (n=1); confusing (n=2)
Technical Manuals Overall	0		0			
NATOPS	0		0			
FTI	0		0		1	Still useful, but outdated, which caused some confusion (n=1)
Course Rules	0		0			
Technical Manuals (Other)	0		0			
Avenger Modules	1		0		1	Mission Stage had no use for them (n=1)
360-degree Videos Overall	0		0			
360-degree Videos with Oculus Goggles	5	Less useful than practice in VR Trainers (n=2), rarely used (n=1) or rarely used after the first few weeks (n=1)	3	Not useful after 1st month or later in syllabus (n=2), less useful than VR practice (n=1)	4	Not used in Mission Stage (n=1); SNAs had already learned the basics by Mission Stage (n=1); useful in Contact and Formation training, but not beyond (n=1)

Course Materials	Pre-Flight Stage (17 respondents) Count	Reasons	Qualification Stage (6 respondents) Count	Reasons	*Mission Stage (14 respondents)* Count	Reasons
360-degree Videos via YouTube	0		0			
VR Trainers Overall	0		0			
VR Trainer with PilotEdge	0		0		1	Not used or needed in Mission Stage (n=1)
VR Trainer with an Instructor (in-person)	0		0			
VR Training Solo Practice	0		0			
CloudAhoy	1	Not used in this Stage	1	Not used	2	Never used (n=1); display is cluttered after Forms sequence and high work (n=1)
ForeFlight	0		0			
General iPad Usage	0		0			
Google Drive	0		0			
Detachment IP and Stash Support	0		0			
Detachment IP Support	0		0			
Detachment Stash Support	0		0		1	

Table 18. Recommendations for changes to course materials

Type of Comment	Pre-Flight Stage (17 respondents)		Qualification Stage (6 respondents)		*Mission Stage (14 respondents)*	
	Count	Reasons	Count	Reasons	Count	Reasons
Technical Manuals	0		0		1	In the Mission Stage, have instructors explain FTI and Course Rules deviations from standards up front (n=1)
VR Trainers	3	Create a stick with force feedback (n=1), make the VR trainers more reliable (n=1), put an FMS capability in VR Trainers (n=1)	0		1	More reliable VR trainers (n=1)
Training Timeline	3	More classroom instruction (n=1), put VR events before traditional SIM events (n=1), breakdown the overall system review into single-system reviews across different days (n=1)	1	More classroom instruction (n=1)	3	More VR training with an IP in preparation for the Mission Stage (n=1); more in-class lectures (n=1); more hands-on ground school (n=1)
MCG / Curriculum Guidance	4	Clarify syllabus flow (n=1), list prerequisite modules and events for each event (n=1), show how course materials will relate to each event (n=1), give instructions on study materials to focus on (n=1)	3	Make MCG easier to understand (n=1), simpler MCG broken down by requirements in each Stage (n=1), make MCG consistent with gradebook (n=1)	7	Improve MCG (n=1); clarify syllabus flow (n=1); make MCG easier to navigate (n=2); make MCG consistent with gradebook (n=1); explain MCG to SNAs (n=1); broadcast MCG changes to SNAs (n=1)
CloudAhoy	0		0		1	
Instructors	0		1	Have instructors clarify planning objectives (n=1)		

Type of Comment	Pre-Flight Stage (17 respondents) Count	Reasons	Qualification Stage (6 respondents) Count	Reasons	*Mission Stage (14 respondents)* Count	Reasons
Growing Pains	2	Do not change profiles close to the date they will be completed (n=1), make more 360 videos for later in the syllabus (n=1)	0			
Resources	2	Make Google Drive easier to navigate; make an iPad-friendly syllabus that indicates progress	0			
No Changes Needed	0		0		2	

10.4.2. Delivery Methods

Table 19. Effectiveness of delivery method

Delivery Method	Pre-Flight Stage (17 respondents)			Qualification Stage (6 respondents)			*Mission Stage (14 respondents)*		
	Mdn	*IQR*	*N/A*	*Mdn*	*IQR*	*N/A*	*Mdn*	*IQR*	*N/A*
At-home Coursework	4	1	1	4	1.5	0	4	0.5	3
Avenger Modules (2D and 360 videos)	5	2	1	3.5	1	0	4	1	2
In-person Lectures	5.5	2	1	4	2	1	5	2	2
Detachment IP and Stash Support	6	0	1	4.5	1.75	0	6	0	1
Solo VR and Simulator Practice (no IP)	5	2	1	5.5	1.75	0	6	1	1
VR events with an IP	6	0	1	6	1.5	0	6	0	1
PilotEdge	6	0	1	6	1.5	0	6	0	1
UTD	5	1.75	7	4	0	3	4	1.75	4
IFT	5	1	8	5	1	4	4.5	1	4
Augmented Reality (UTD with VR headset)	5	2	14	N/A	N/A	6	5	2.5	11
OFT	6	0	1	5.5	1.25	2	6	1	1
Qualification Flight Events	6	0.5	10	5	1	1	6	1	1
Mission Flight Events	4	1	14	N/A	N/A	6	6	2	1

Note. Mdn = Median rating on a 0-5 scale, IQR = interquartile range, N/A = number of "N/A" or missing responses. Median and interquartile range are employed instead of mean and standard deviation to avoid assuming equal intervals between scale responses. Cells with underlined text indicate areas in which SNAs may not have had enough experience to provide realistic rankings.

Table 20. Engagement with the material

Delivery Method	Pre-Flight Stage (17 respondents)			Qualification Stage (6 respondents)			*Mission Stage (14 respondents)*		
	Mdn	*IQR*	*N/A*	*Mdn*	*IQR*	*N/A*	*Mdn*	*IQR*	*N/A*
At-home Coursework	4	2	1	4.5	2.5	0	4	1	2
Avenger Modules (2D and 360 videos)	4	1	1	4	0.75	0	4	1	2

Delivery Method	Pre-Flight Stage (17 respondents)			Qualification Stage (6 respondents)			*Mission Stage (14 respondents)*		
	Mdn	*IQR*	*N/A*	*Mdn*	*IQR*	*N/A*	*Mdn*	*IQR*	*N/A*
In-person Lectures	6	1.25	1	5	1.5	0	5	1.25	2
Detachment IP and Stash Support	6	0	1	6	0	0	6	0	1
Solo VR and Simulator Practice (no IP)	6	1.25	1	6	0.75	0	6	1	1
VR events with an IP	6	0	1	6	0	0	6	0	1
PilotEdge	6	0	1	6	0	0	6	0	1
UTD	6	2	7	5	1	3	6	0.75	4
IFT	5	2	8	6	0	5	6	1.25	6
Augmented Reality (UTD with VR headset)	4	2	14	N/A	N/A	6	6	0	12
OFT	6	0	1	6	0	2	6	0	1
Qualification Flight Events	5	2	11	6	0	1	6	0	1
Mission Flight Events	4	1	14	N/A	N/A	6	6	0	1

Note. Mdn = Median rating on a 0-5 scale, IQR = interquartile range, N/A = number of "N/A" or missing responses. Median and interquartile range are employed instead of mean and standard deviation to avoid assuming equal intervals between scale responses. Cells with underlined text indicate areas in which SNAs may not have had enough experience to provide realistic rankings.

Table 21. Quality of the method

Delivery Method	Pre-Flight Stage (17 respondents)			Qualification Stage (6 respondents)			*Mission Stage (14 respondents)*		
	Mdn	*IQR*	*N/A*	*Mdn*	*IQR*	*N/A*	*Mdn*	*IQR*	*N/A*
At-home Coursework	4	1.5	2	4	0.75	0	4	0.5	3
Avenger Modules (2D and 360 videos)	4	1.5	2	4	1.5	0	4	1	3
In-person Lectures	6	1.5	2	4.5	1.75	0	6	1	3
Detachment IP and Stash Support	6	0	2	6	1.5	0	6	0	2
Solo VR and Simulator Practice (no IP)	6	2	2	5.5	1	0	5	2	2
VR events with an IP	6	0	2	6	1.5	0	6	0.25	2
PilotEdge	6	0	2	5.5	1.75	0	6	1.25	2

Delivery Method	Pre-Flight Stage (17 respondents)			Qualification Stage (6 respondents)			*Mission Stage (14 respondents)*		
	Mdn	*IQR*	*N/A*	*Mdn*	*IQR*	*N/A*	*Mdn*	*IQR*	*N/A*
UTD	6	2	8	3.5	0.5	4	4	2	5
IFT	6	2	10	6	0	5	5	0.5	6
Augmented Reality (UTD with VR headset)	6	0	15	N/A	N/A	6	4.5	0.5	12
OFT	6	0	2	6	0.5	2	6	1	2
Qualification Flight Events	5.5	1.75	11	6	0	1	6	0	3
Mission Flight Events	5	1	14	N/A	N/A	6	6	0.5	2

Note. Mdn = Median rating on a 0-5 scale, IQR = interquartile range, N/A = number of "N/A" or missing responses. Median and interquartile range are employed instead of mean and standard deviation to avoid assuming equal intervals between scale responses. Cells with underlined text indicate areas in which SNAs may not have had enough experience to provide realistic rankings.

Table 22. Understanding of the material

Delivery Method	Pre-Flight Stage (17 respondents)			Qualification Stage (6 respondents)			*Mission Stage (14 respondents)*		
	Mdn	*IQR*	*N/A*	*Mdn*	*IQR*	*N/A*	*Mdn*	*IQR*	*N/A*
At-home Coursework	4	2	1	4	0	1	5	2	3
Avenger Modules (2D and 360 videos)	5	2	1	4	0	0	5	2	3
In-person Lectures	5	2	1	4	1.5	0	5	1	3
Detachment IP and Stash Support	6	0	1	4	1.5	0	6	1	2
Solo VR and Simulator Practice (no IP)	5.5	2	1	5.5	1.75	0	5.5	1.25	2
VR events with an IP	6	0	1	6	1.5	0	6	0	2
PilotEdge	6	1.25	1	6	1.5	0	6	1	2
UTD	4.5	1.75	7	4	0	4	4	1	5
IFT	4	2	10	6	0	5	5	1.25	6
Augmented Reality (UTD with VR headset)	5	1	15	N/A	N/A	6	5.5	0.5	12
OFT	5.5	2	1	6	0.25	2	5.5	1	2
Qualification Flight Events	6	2	12	6	1	1	6	1	3
Mission Flight Events	5	1	15	N/A	N/A	6	5	2	2

Delivery Method	Pre-Flight Stage (17 respondents)			Qualification Stage (6 respondents)			*Mission Stage (14 respondents)*		
	Mdn	*IQR*	*N/A*	*Mdn*	*IQR*	*N/A*	*Mdn*	*IQR*	*N/A*

Note. Mdn = Median rating on a 0-5 scale, IQR = interquartile range, N/A = number of "N/A" or missing responses. Median and interquartile range are employed instead of mean and standard deviation to avoid assuming equal intervals between scale responses. Cells with underlined text indicate areas in which SNAs may not have had enough experience to provide realistic rankings.

Table 23. Delivery method's benefit to learning

Delivery Method	Pre-Flight Stage (17 respondents)			Qualification Stage (6 respondents)			*Mission Stage (14 respondents)*		
	Mdn	*IQR*	*N/A*	*Mdn*	*IQR*	*N/A*	*Mdn*	*IQR*	*N/A*
At-home Coursework	5.5	2	1	4	0	0	5	2	2
Avenger Modules (2D and 360 videos)	5	2	1	4	1.5	0	4.5	1	2
In-person Lectures	6	1.25	1	5.5	1.75	0	6	1	2
Detachment IP and Stash Support	6	0	1	5	2	0	6	0	1
Solo VR and Simulator Practice (no IP)	5.5	2	1	5.5	1	0	6	1	1
VR events with an IP	6	0	1	6	1.5	0	6	0	1
PilotEdge	6	0	1	6	0	0	6	1	1
UTD	6	1.5	7	4.5	0.5	4	5	2	4
IFT	6	0.5	9	6	0	5	6	1	7
Augmented Reality (UTD with VR headset)	5	1	14	N/A	N/A	6	6	0	13
OFT	6	0	1	6	0	2	6	0	1
Qualification Flight Events	5.5	1.75	11	6	1	1	6	0	2
Mission Flight Events	6	1	14	N/A	N/A	6	6	0	1

Note. Mdn = Median rating on a 0-5 scale, IQR = interquartile range, N/A = number of "N/A" or missing responses. Median and interquartile range are employed instead of mean and standard deviation to avoid assuming equal intervals between scale responses. Cells with underlined text indicate areas in which SNAs may not have had enough experience to provide realistic rankings.

Table 24. Delivery method's quality of content

Delivery Method	Pre-Flight Stage (17 respondents)			Qualification Stage (6 respondents)			*Mission Stage (14 respondents)*		
	Mdn	*IQR*	*N/A*	*Mdn*	*IQR*	*N/A*	*Mdn*	*IQR*	*N/A*
At-home Coursework	4.5	2	1	4	0	0	4	1.5	3
Avenger Modules (2D and 360 videos)	4.5	2	1	4	1.5	0	5	2	3
In-person Lectures	5	2	1	5.5	1.75	0	5	1.5	3
Detachment IP and Stash Support	6	0	1	5	2	0	6	0	2
Solo VR and Simulator Practice (no IP)	5.5	2	1	5.5	1	0	5	2	2
VR events with an IP	6	0	1	6	0	0	6	1	2
PilotEdge	6	0	1	6	0	1	6	1	2
UTD	5.5	2	7	4	1	4	5	2	5
IFT	4	1.25	9	6	0	5	5.5	1	6
Augmented Reality (UTD with VR headset)	5.5	0.5	15	N/A	N/A	6	6	0	12
OFT	6	2	1	5.5	1.25	2	5.5	1.25	2
Qualification Flight Events	5.5	1.75	11	5	2	1	6	1	3
Mission Flight Events	5	1	14	N/A	N/A	6	5.5	1	2

Note. Mdn = Median rating on a 0-5 scale, IQR = interquartile range, N/A = number of "N/A" or missing responses. Median and interquartile range are employed instead of mean and standard deviation to avoid assuming equal intervals between scale responses. Cells with underlined text indicate areas in which SNAs may not have had enough experience to provide realistic rankings.

Table 25. Understanding of expectations

Delivery Method	Pre-Flight Stage (17 respondents)			Qualification Stage (6 respondents)			*Mission Stage (14 respondents)*		
	Mdn	*IQR*	*N/A*	*Mdn*	*IQR*	*N/A*	*Mdn*	*IQR*	*N/A*
At-home Coursework	4	2	1	5	2.75	0	4.5	2	2
Avenger Modules (2D and 360 videos)	4	1	1	5	2	0	4	1.25	2
In-person Lectures	5.5	1.25	1	5	2	0	5.5	1.25	2
Detachment IP and Stash Support	6	0	1	4	1.5	0	5.5	1	2

Delivery Method	Pre-Flight Stage (17 respondents)			Qualification Stage (6 respondents)			*Mission Stage (14 respondents)*		
	Mdn	*IQR*	*N/A*	*Mdn*	*IQR*	*N/A*	*Mdn*	*IQR*	*N/A*
Solo VR and Simulator Practice (no IP)	5	2	2	5.5	1.75	0	5	1	1
VR events with an IP	6	0.25	1	5	2	1	6	1	1
PilotEdge	6	1	1	5	2	1	5	1	1
UTD	5	1.75	7	3	1	4	5	1.75	4
IFT	5	2	9	6	0	5	5	1	7
Augmented Reality (UTD with VR headset)	4	2.5	14	N/A	N/A	6	5	0	13
OFT	5	2	1	5.5	1.25	2	6	1	1
Qualification Flight Events	5	1.5	11	4	1	1	5.5	1.25	2
Mission Flight Events	5	1	14	N/A	N/A	6	4	3	1

Note. Mdn = Median rating on a 0-5 scale, IQR = interquartile range, N/A = number of "N/A" or missing responses. Median and interquartile range are employed instead of mean and standard deviation to avoid assuming equal intervals between scale responses. Cells with underlined text indicate areas in which SNAs may not have had enough experience to provide realistic rankings.

Table 26. Most beneficial delivery method

	Pre-Flight Stage (17 respondents)		Qualification Stage (6 respondents)		*Mission Stage (14 respondents)*	
Delivery Method	Count	Reasons	Count	Reasons	Count	Reasons
At-home Coursework	2	Good for gaining GK (n=1)	0		0	
Avenger Modules (2D and 3D videos)	1		0		1	
2D videos	0		0		0	
3D videos	1		0		0	
In-person Lectures	0		0		1	Opportunity to get questions answered in person (n=1)
Detachment IP and Stash Support	2		0		0	
IP Support	4	It was helpful to have IPs in the same room (n=1), IPs gave context to information received in at-home coursework (n=1), IPs were the best way to absorb material (n=1), IPs were available to ask questions (n=1)	0		6	Available to explain topics (n=1), help with event planning and approval (n=1), useful debriefs after flights (n=1), especially useful for Instruments due to insufficient ground school (n=1)
Stash Support	0		0		0	
VR and Simulator Practice	0		0		1	Opportunity to get questions answered in person (n=1)
VR Trainers Overall	3	Good for course rules (n=2), communications (n=1), sight picture (n=1), and practicing procedures for OFT events (n=1)	0		1	
Solo VR and Simulator	0		0		0	

Delivery Method	Pre-Flight Stage (17 respondents) Count	Reasons	Qualification Stage (6 respondents) Count	Reasons	*Mission Stage (14 respondents)* Count	Reasons
Practice (no IP)						
Solo VR Practice with PilotEdge	0		0		1	Practice responding to contingencies (n=1)
Solo VR Practice	0		1	SNAs know what they need to work on (n=1)	0	
Solo Simulator Practice	0		0		0	
VR events with an IP	3	Good for preparing for an event (n=1), SNAs knew the purpose was to learn (n=1), gave opportunities to get questions answered (n=1)	1	Addressed skills that were not addressed in readings or modules (n=1)	1	One of the most direct methods of teaching course material (n=1)
VR events with an IP and PilotEdge	1	Realism (n=1)	1		0	
PilotEdge	0		2	In conjunction with VR, it showed what to expect in the plane (n=1) and was good for sight picture, communications, and procedures (n=1)	1	
UTD	0		0		0	
IFT	1		0		0	
Augmented Reality (UTD with VR headset)	0		0		0	
OFT	2	Good for developing awareness and stick skills without the negative training of VR trainers (n=1), most realistic sight picture	0		2	One of the most direct methods of teaching course material (n=1); advanced EP OFT events were helpful (n=1)

Delivery Method	Pre-Flight Stage (17 respondents) Count	Reasons	Qualification Stage (6 respondents) Count	Reasons	*Mission Stage (14 respondents)* Count	Reasons
		(n=1), most realistic feel (n=1)				
Flight Events Overall	0		0		2	Especially useful for instruments due to insufficient ground training (n=1); one of the most direct methods of teaching course material (n=1)
Qualification Flight Events	0		0		0	
Mission Flight Events	0		1	There is no substitute for real flights (n=1)	3	There are no substitutes for real flights (n=1); gave exposure to new concepts (n=1); highlighted performance weaknesses and gave opportunities for improvement (n=1)

Table 27. Least beneficial delivery method

Delivery Method	Pre-Flight Stage (17 respondents) Count	Reasons	Qualification Stage (6 respondents) Count	Reasons	*Mission Stage (14 respondents)* Count	Reasons
At-home Coursework	0		2	Did not have enough understanding to make it useful before seeing concepts in action (n=1)	2	Flexible scenarios led to constant changes to procedures in reaction to contingencies (n=1)
Avenger Modules (2D and 3D videos)	2	Relied on FTI because modules were not in-depth enough (n=1), reading source publications and asking	0		1	Too little study guidance- needs a study guide (n=1)

Delivery Method	Pre-Flight Stage (17 respondents) Count	Reasons	Qualification Stage (6 respondents) Count	Reasons	*Mission Stage (14 respondents)* Count	Reasons
		instructors was a better use of time (n=1)				
2D videos	1	Need some touch-ups (n=1)	0		0	
3D videos	3	Reading source publications and asking instructors was a better use of time (n=1); not useful in daily routine because SNAs were in the SIM building (n=1)	1	Did not work (n=1)	2	Not useful in Mission Stage (n=1); too much effort for too little benefit (n=1)
In-person Lectures	0		0		1	Needed more in preparation for Mission Stage (n=1)
Detachment IP and Stash Support	0		1	Dropped off when flights started (n=1)	0	
IP Support	0		0		0	
Stash Support	0		0		1	
VR and Simulator Practice	0		0		0	
VR Trainers Overall	0		0		1	Not used in Mission Stage (n=1)
Solo VR and Simulator Practice (no IP)	1	Only useful for procedures due to unrealistic control feel (n=1)	0		0	
Solo VR Practice with PilotEdge	0		0		0	
Solo VR Practice	0		0		0	
Solo Simulator Practice	0		0		0	

Delivery Method	Pre-Flight Stage (17 respondents) Count	Reasons	Qualification Stage (6 respondents) Count	Reasons	*Mission Stage (14 respondents)* Count	Reasons
VR events with an IP	0		0		0	
VR events with an IP and PilotEdge	0		0		0	
Simulator Events with an Instructor	0		1	Some instructors treated events as a test rather than a learning opportunity (n=1)	0	
PilotEdge	0		0		0	
UTD	2	Never used (n=1); useful but less than other methods (n=1)	0		1	No effect on performance (n=1)
IFT	2	Never used (n=1); useful but not reliable leading to wasted time (n=1)	0		0	
Augmented Reality (UTD with VR headset)	0		0		0	
OFT	0		0		0	
Flight Events Overall	0		0		0	
Qualification Flight Events	0		0		0	
Mission Flight Events	0		0		0	
None	0		1		0	

Table 28. Recommendations for changes to delivery methods

Type of Comment	Pre-Flight Stage (17 respondents)		Qualification Stage (6 respondents)		*Mission Stage (14 respondents)*	
	Count	Reasons	Count	Reasons	Count	Reasons
VR Trainers	3	Make VR trainers more reliable (n=1); provide an instructor microphone (n=1); use more varied takeoff and recovery locations in VR events (n=1)	0		1	
Simulators	0		1	Set the expectation with instructors that simulator events are for learning; not testing (n=1)	0	Ensure that VR homework has target outcomes (n=1)
Training Timeline	6	More in-person lecture (n=2); more OFTs (n=1); group contact SIMs together and instrument SIMs together (n=1); make the syllabus flow more like the traditional syllabus (n=1); change class times to maximize study time available (n=1)	2	More in-person lectures approaching the Mission Stage (n=1); more VR events with PilotEdge approaching the Mission Stage (n=1)	7	More in-person lectures (n=3); more ground school (n=1); more VR training with an instructor (n=1); more review sessions (n=1); alternate days of double mission flights with chair fly days to enhance efficiency (n=1)
Instructor Resistance to Avenger	1	teach SIM instructors about Avenger gradebooks to minimize frustration (n=1)	0		0	
Instructor Availability	0		0		1	Ensure an IP is in the det space to facilitate learning (n=1)
Curriculum Guidance	0		0		2	Clarify expectations before each Stage begins (n=1); slightly more defined goals in Mission Stage (n=1)

Type of Comment	Pre-Flight Stage (17 respondents)		Qualification Stage (6 respondents)		*Mission Stage (14 respondents)*	
	Count	Reasons	Count	Reasons	Count	Reasons
Quality of Resources	2	Make Avenger module videos more coherent (n=1); have instructors give more feedback about expected progress (n=1)	1	More SNA/on-wing interaction to discuss programs (n=1)	0	
Growing Pains	2	Give more advance knowledge of upcoming events (n=1); standardize expectations; execution; and evaluation for traditional SIM events (n=1)	1	More 360 videos (n=1)	2	Clarify Mission Stage expectations (n=1); standardize requirements between IPs and for all SNAs
No Changes Needed	0		0		1	

10.4.3. SIM Instructors

Table 29. "To what extent did the SIM instructors ..."

Item	Pre-Flight Stage (17 respondents)			Qualification Stage (6 respondents)			*Mission Stage (14 respondents)*		
	Mdn	*IQR*	*N/A*	*Mdn*	*IQR*	*N/A*	*Mdn*	*IQR*	*N/A*
Grading according to Course Training Standards (CTS)	4	1.25	1	5.5	1.75	0	4	1	1
Knowledge of the aircraft and its systems	6	0	1	6	0	0	6	1	1
Adherence to up-to-date checklists, SOPs, references (FTI, NATOPS, Course Rules, etc.), and safety procedures	6	1.25	1	5.5	1.75	0	5	1	1
Explains new concepts in clear and relatable terms based on student's prior knowledge	6	2	1	4.5	2.5	0	4	1	1
Sets clear expectations of the student's performance and knowledge/understanding	4	2	1	4.5	2.5	0	4	0	1
Provides clear guidance on how to learn from and correct mistakes	5.5	2	1	4	2.75	0	5	1	1
Professionalism, military bearing, and enthusiasm for student learning	6	1.25	1	5	1.5	0	5	1	1
Encouraged student to take on new challenges	6	2	1	5.5	1.75	0	5	1	1
Value and effectiveness of brief	5	2	1	4	0.75	0	4	1	1
Value and effectiveness of debrief	6	2	1	4.5	2.5	0	5	1	1
Grading according to Course Training Standards (CTS)	4	1.25	1	5.5	1.75	0	4	1	1
Knowledge of the aircraft and its systems	6	0	1	6	0	0	6	1	1
Adherence to up-to-date checklists, SOPs, references (FTI, NATOPS, Course Rules, etc.), and safety procedures	6	1.25	1	5.5	1.75	0	5	1	1

Note. Mdn = Median rating on a 0-5 scale, IQR = interquartile range, N/A = number of "N/A" or missing responses. Median and interquartile range are employed instead of mean and standard deviation to avoid assuming equal intervals between scale responses.

Table 30. What made SIM events most effective for learning

Type of Comment	Pre-Flight Stage (17 respondents) Count	Reasons	Qualification Stage (6 respondents) Count	Reasons	*Mission Stage (14 respondents)* Count	Reasons
Instructor characteristics	7	Giving advice and clarifying concepts during the brief (n=1); approaching event with intention of coaching (n=2) and helping SNAs learn from mistakes (n=1); providing feedback on how to correct mistakes (n=1); teaching during the event (n=2) and during debriefs (n=1)	2	Provide direction for future learning during debrief (n=1), coaching on decision-making (n=1)	3	Sharing their experiences (n=1); instructor intention of coaching (n=1); instructor identifying and correcting errors (n=1)
Traditional simulator device benefits	5	Getting comfortable with controls while strapped in and in full gear (n=1); control feel (n=2) which helps SNAs develop stick skills (n=1); FMS usage (n=1)	0		0	
VR Trainer device benefits	1	Sight picture (n=1); communications training (n=1)	0		0	
Event characteristics	1	Study expectations made clear prior to the event (n=1)	1	Treat SIMs as a learning opportunity instead of a test (n=1)	3	Sharing their experiences (n=1); instructor intention of coaching (n=1); instructor identifying and correcting errors (n=1)
Types of events	3	Checklist SIMs (n=1); EP SIMs (n=1); Contact SIMs (n=1)	0		2	EP SIM events were great for learning EPs and how to respond to contingencies (n=2)
Simulator event benefits	7	Experience gained (n=2); repetition of procedures (n=1); encouraged SNAs to challenge themselves (n=1); ability to make and learn from mistakes (n=1); use of discussion items (n=1);	3	Practicing what had been studied (n=1); instruction by instructors on new material (n=1); learning	7	Getting initial exposure to topics (n=1); seeing concepts introduced prior to flying (n=1); practicing skills in a controlled environment prior to flying (n=2); making mistakes in a

Type of Comment	Pre-Flight Stage (17 respondents) Count	Reasons	Qualification Stage (6 respondents) Count	Reasons	*Mission Stage (14 respondents)* Count	Reasons
		briefs provide constant challenge with introduction of new material (n=1)		procedure compliance (n=1)		controlled environment prior to flying (n=1); building muscle memory (n=1); building sight picture (n=1)

Table 31. What made SIM events least effective for learning

Type of Comment	Pre-Flight Stage (17 respondents) Count	Reasons	Qualification Stage (6 respondents) Count	Reasons	*Mission Stage (14 respondents)* Count	Reasons
Instructor characteristics	7	Resistance to Avenger program (n=1); instructor grading based on resistance to Avenger program rather than CTS (n=2); instructor not fostering a learning environment (n=1); inconsistent expectations (n=2); unrealistically high performance expectations (n=1); demeaning SNAs (n=1)	1	Instructor not explaining grades (n=1)	6	Resistance to Avenger program (n=1); grading based on resistance to Avenger program rather than CTS (n=1); following a script too closely (n=1); inconsistent expectations (n=1); unrealistically high performance expectations (n=1); demeaning SNAs for not flying well (n=1)
Traditional simulator device disadvantages	0		0		1	Unrealistic control feel (n=1)
VR Trainer device disadvantages	2	Not reliable (n=1); control inputs inaccurate compared to OFT (n=1)	0		0	
Event characteristics	3	Too many objectives for the time period (n=2); which leads to poor learning (n=1)	3	SIM events used as a test instead of a learning opportunity (n=2); too many objectives for	2	SIM events used as a test instead of a learning opportunity (n=1); some irrelevant SSRs and discussion items (n=1)

Type of Comment	Pre-Flight Stage (17 respondents) Count	Reasons	Qualification Stage (6 respondents) Count	Reasons	*Mission Stage (14 respondents)* Count	Reasons
				the time period, leading to incompletes or low grades (n=1)		
Types of events	0		0		0	
Simulator event issues	0		0		1	
Training timeline	4	Downtime between SIMs (n=1); lack of exposure before SIMs (n=1); SIMs not ordered correctly (n=1); insufficient preparation for instrument SIMs (n=1)	1	Redundant SIM events (n=1)	0	
Growing pains	1	Inconsistency in SNA profiles (n=1)	0		2	Instructors not understanding the Mission Stage (n=1); unclear expectations due to not Avenger syllabus (n=1)
Nothing was ineffective	0		0		1	

Table 32. Recommendations to SIM instructors to improve training

Type of Comment	Pre-Flight Stage (17 respondents) Count	Reasons	Qualification Stage (6 respondents) Count	Reasons	*Mission Stage (14 respondents)* Count	Reasons
Instructor characteristics	6	Accept the Avenger program (n=1); grade based on the CTS rather than attitude towards Avenger (n=1); Provide guidance and clarification after the brief (n=1); ensure	1	Act as a teacher (n=1)	5	Teach the SNA instead of allowing poor performance to continue (n=1); grade according to the Avenger MCG; have sympathy for SNAs (n=1); keep a positive attitude instead of

Type of Comment	Pre-Flight Stage (17 respondents) Count	Reasons	Qualification Stage (6 respondents) Count	Reasons	*Mission Stage (14 respondents)* Count	Reasons
		criticism is constructive and accompanied by teaching (n=1); teach the SNA while mistakes are being made rather than letting mistakes continue (n=1)				demeaning SNAs (n=1); foster a learning environment (n=1)
Event characteristics	2	Treat SIMs as a learning opportunity instead of a test (n=2)	3	Although it may be infeasible, it would be useful to have more time for debrief and SNA questions (n=1); approach SIM events as a learning opportunity instead of a test (n=2)	1	Approach SIM events as a learning opportunity instead of a test (n=1)
Avenger syllabus	1	Standardize expectations (n=1)	0		1	Standardize requirements (n=1)
Growing pains	5	Learn about the Avenger program (n=2), learn about Avenger gradebook and expectations (n=1), learn about the Avenger syllabus (n=1), standardize expectations between instructors (n=1)	1	Become familiar with the Avenger syllabus (n=1)	5	Learn about the Avenger syllabus (n=1); learn about Avenger expectations (n=2) and gradebook (n=1)

10.4.4. Flight Instructors

Table 33. "To what extent did the flight instructors ..."

Item	Pre-Flight Stage (17 respondents)			Qualification Stage (6 respondents)			*Mission Stage (14 respondents)*		
	Mdn	*IQR*	*N/A*	*Mdn*	*IQR*	*N/A*	*Mdn*	*IQR*	*N/A*
Grading according to Course Training Standards (CTS)	6	1	8	6	0	0	5	2	1
Knowledge of the aircraft and its systems	6	0	7	6	0.75	0	6	0	1
Adherence to up-to-date checklists, SOPs, references (FTI, NATOPS, Course Rules, etc.), and safety procedures	6	0	6	6	0	0	6	1	1
Explains new concepts in clear and relatable terms based on student's prior knowledge	6	0	6	6	0	0	6	1	1
Sets clear expectations of the student's performance and knowledge/understanding	6	1	6	6	0.75	0	5	2	1
Provides clear guidance on how to learn from and correct mistakes	6	0.5	6	6	0.75	0	6	2	1
Professionalism, military bearing, and enthusiasm for student learning	6	0	6	6	0	0	6	0	1
Encouraged student to take on new challenges	6	0	6	6	0	0	6	0	1
Value and effectiveness of brief	6	1	6	6	0	0	6	1	1
Value and effectiveness of debrief	6	1	6	6	0	0	6	0	1
Grading according to Course Training Standards (CTS)	6	1	8	6	0	0	5	2	1
Knowledge of the aircraft and its systems	6	0	7	6	0.75	0	6	0	1
Adherence to up-to-date checklists, SOPs, references (FTI, NATOPS, Course Rules, etc.), and safety procedures	6	0	6	6	0	0	6	1	1

Note. Mdn = Median rating on a 0-5 scale, IQR = interquartile range, N/A = number of "N/A" or missing responses. Median and interquartile range are employed instead of mean and standard deviation to avoid assuming equal intervals between scale responses.

Table 34. What made flight events most effective for learning

Type of Comment	Pre-Flight Stage (17 respondents)		Qualification Stage (6 respondents)		*Mission Stage (14 respondents)*	
	Count	Reasons	Count	Reasons	Count	Reasons
Instructor characteristics	1	Correcting errors (n=1)	3	Constructive criticism (n=1); allowing SNAs to make and correct mistakes (n=1); being calm and allowing SNAs to make mistakes that the instructor then corrects (n=1)	4	In-depth debrief about each Stage of the event (n=1); take controls while explaining a concept to the SNA (n=1); correcting errors as they occur (n=1)
Event characteristics	0		1	Always something new to learn (n=1)	7	Varied skillsets require thinking and preparation (n=1); introduction of unexpected contingencies (n=2); clear expectations (n=1); flight splits or joins helped SNAs to put together previously-learned concepts (n=1); always treated as a learning opportunity (n=2)
Event benefits	0		2	Actual experience with the aircraft (n=2)	5	Actual experience with the aircraft (n=3); actual experience with the aircraft in different scenarios (n=1); learning from mistakes (n=1); repetitions (n=1)
Training timeline	0		0		1	Flexibility in flight scheduling kept SNAs flying frequently (n=1)
N/A- Have not flown yet	13		0		0	

Table 35. What made flight events least effective for learning

Type of Comment	Pre-Flight Stage (17 respondents) Count	Reasons	Qualification Stage (6 respondents) Count	Reasons	*Mission Stage (14 respondents)* Count	Reasons
Instructor characteristics	0		1	Being overly corrective and not allowing SNAs to fail (n=1)	2	Not having time to answer all questions (n=1); not correcting errors as they occur (n=1)
Event characteristics	0		0		2	Longer cross country trip requires more formation work and B&Rs, which is not ideal (n=1); Course Rules coming back from Goliad was unnecessary (n=1)
Avenger syllabus	0		0		2	Non-standardized expectations (n=1); emphasis on required items reduced flexibility to address SNA needs (n=1)
SNA characteristics	0		0		2	Having different partners for different flights led to needs for different SSRs and prevented some items from being signed off on certain flights (n=1); stress combined with several days out of the aircraft degraded performance (n=1)
Training timeline	0		1	Instrument Stage was repetitive (n=1)	0	
Growing pains	0		0		2	Non-Avenger IPs do not understand the Avenger syllabus or expectations (n=1); irrelevant required items that were carried over from the Air Force (n=1)

Type of Comment	Pre-Flight Stage (17 respondents) Count	Reasons	Qualification Stage (6 respondents) Count	Reasons	*Mission Stage (14 respondents)* Count	Reasons
Nothing made flight events ineffective	0		1		1	
N/A- Have not flown yet	14		0		0	

Table 36. Recommendations to flight instructors to improve training

Type of Comment	Pre-Flight Stage (17 respondents) Count	Reasons	Qualification Stage (6 respondents) Count	Reasons	*Mission Stage (14 respondents)* Count	Reasons
Instructor characteristics / availability	0		1	Allow SNAs to fail more (n=1)	3	Give instructors more time to answer questions, either by a higher instructor-to-student ratio or by more spaced-out flights (n=1); identify and correct repeat errors in individual SNAs (n=1); consistent grading, expectations, and attitudes (n=1)
Event characteristics	0		0		2	More unexpected contingencies (n=1)
Training timeline	0		0		1	For SNAs with multiple days outside the aircraft, use the first flight to identify problem areas, second flight to work on problems, and assume the problems are addressed for the third flight (n=1)

Type of Comment	Pre-Flight Stage (17 respondents) Count	Reasons	Qualification Stage (6 respondents) Count	Reasons	*Mission Stage (14 respondents)* Count	Reasons
Resources	0		0		1	Create an overall quick profile outside the gradebook for instructors to consult (n=1)
SNA characteristics	0		0		1	All SNAs should have a mission Stage partner to minimize redundancy in events (n=1)
MCG / Curriculum guidance	0		1	Standardize formation training (n=1)	0	
Growing pains	0		1	Communication and consistency between IPs (n=1)	0	
No changes needed	3	Instructors are excellent (n=3)	1	Instructors are excellent (n=1)	1	
N/A- Have not flown yet	12					

10.4.5. Summary Feedback Section

Table 37. Recommendations to improve Avenger training

Type of Comment	Pre-Flight Stage (17 respondents) Count	Reasons	Qualification Stage (6 respondents) Count	Reasons	*Mission Stage (14 respondents)* Count	Reasons
Training timeline (Instruments)	7	More VR instrument events (n=1); increase the proportion of the syllabus focused on instruments (n=1); provide a lecture	1	Make first 4-6 Qualification Stage flights Contact intensive with less focus on Instruments (n=1)	4	Create an Instrument ground school syllabus; reduce the number of Mission flights and increase the number of Instrument and Qualification flights to better prepare SNAs for Mission Stage (n=1);

Type of Comment	Pre-Flight Stage (17 respondents) Count	Reasons	Qualification Stage (6 respondents) Count	Reasons	*Mission Stage (14 respondents)* Count	Reasons
		on plates, briefs, and picking up clearances before instrument SIMs (n=1); do not mix instrument and contact events in close succession (n=1); revise instrument training schedule so that RNAV is introduced before learning how to plug in an RNAV approach (n=1); revise instrument training schedule to reduce the number of items being introduced at one time (n=1); follow the traditional method of having an instrument ground school (n=1)				Introduce in-depth fuel planning and altitude planning for VFR/IFR flights in VR Sims for Instrument and Navigation (n=1); create combined Contact/Instrument flights in which the first half is Contact and the second half is Instrument (n=1)
Training timeline (other)	7	More reps in traditional SIMs (n=1); more classroom lectures before SIMs (n=1); more VR training for procedures (n=1); familiarization flight during preflight to improve motivation (n=1); familiarization	0		2	More VR training with instructor, including 1-2 events just before or during Mission Stage (n=1); more hands-on in-person learning (n=1)

Type of Comment	Pre-Flight Stage (17 respondents) Count	Reasons	Qualification Stage (6 respondents) Count	Reasons	*Mission Stage (14 respondents)* Count	Reasons
		flight during SIM Stage to boost understanding of flying procedures (n=1); more time between SIM events when double pumped (n=1); more group events like Pattern Parties with 3-4 SNAs to 1 instructor (n=1);				
Events	1	Ensure that VR and SIM events are based on the same information (n=1)	1	Provide more pass/fail SIM events with IPs to encourage SNAs to ask questions about things they do not understand (n=1)	0	
Clarity	3	Provide clarity (n=1); provide expectations for each stage (n=1); provide more detail on chapters and modules to study in preparation for a SIM event (n=1)	2	Consistency in expectations (n=1), concrete expectations (n=1)	10	More clarity and consistency early on (n=1); clarify Mission Stage expectations in advance (n=1); introduce discuss items to flight events to guide relevant academic learning (n=1); explain expectations for SNAs in Mission events to avoid dangerous situations (n=1); explain the MCG (n=1); set profile, expectation, and requirements ahead of events (n=1); more standardized content (n=1); more standardized grading requirements (n=1); set expectations from the beginning (n=1); Mission Stage needs a solid plan so that

Type of Comment	Pre-Flight Stage (17 respondents) Count	Reasons	Qualification Stage (6 respondents) Count	Reasons	*Mission Stage (14 respondents)* Count	Reasons
						Instructors and SNAs understand expectations (n=1)
Efficiency	0		0		1	Only require morning brief for those who are going to fly or can go without breaking crew rest requirements (n=1)
Performance expectations	0		0		1	Hold SNAs to GK expectations (n=1)
Instructors	0		0		1	Instructors should be treated as a teammate in Mission Stage so that SNAs can learn as part of crew (n=1)
Growing pains	1		2	More 360 videos (n=1)	0	
No changes needed	1		2	Growing pains are being addressed (n=1)	0	

Table 38. Additional comments on Project Avenger

Type of Comment	Pre-Flight Stage (17 respondents) Count	Reasons	Qualification Stage (6 respondents) Count	Reasons	*Mission Stage (14 respondents)* Count	Reasons
Advantages of Avenger	5	Avenger works well or is excellent (n=2), SNAs are very prepared for flying compared to traditional SNAs (n=1), SNAs have a strong understanding of course rules and communications (n=1), knowing the schedule a week in advance is beneficial (n=1)	0		0	

Type of Comment	Pre-Flight Stage (17 respondents) Count	Reasons	Qualification Stage (6 respondents) Count	Reasons	*Mission Stage (14 respondents)* Count	Reasons
Disadvantages of Avenger	2	Morale was low towards the end of the preflight Stage due to a large number of SIMs with no flights (n=1); it was difficult to try to do so many things at once as new aviators (n=1)	0		2	NSS puts Avenger SNAs at a disadvantage by not accurately representing performance (n=2)
Advantages of detachment model	2	Helpful (n=1); det space encourages collaboration with other SNAs and instructors (n=1)	0		0	
VR technology	2	VR trainers were mostly useful for early course rules, procedures, and landing pattern, but otherwise cause negative training (n=1); VR events were very dissimilar to SIM events in the early stages (n=1)	0		1	360 videos in Oculus were underutilize and could be used to introduce concepts directly (n=1)
Training timeline	2	Schedule is so intense that many SNAs struggled to take care of themselves and could not sleep due to stress (n=1); Sim schedule left little time for addressing weaknesses before the next SIM (n=1)	3	Make VNAV a part of Contact training (n=1), Make Navigation flights into Instrument flights (n=1), require a qualification check type of flight once per week during Formation training (n=1)	3	Insufficient ground school before SIMs (n=2); space flight schedules out more consistently to help SNAs process what they learned (n=1)
Avenger syllabus	0		1	Standardize Formation training (n=1)	0	

Type of Comment	Pre-Flight Stage (17 respondents) Count	Reasons	Qualification Stage (6 respondents) Count	Reasons	*Mission Stage (14 respondents)* Count	Reasons
Efficiency	0		1	Have Q4T-prepared SNAs on standby in case of formation flight cancellations; requiring SNAs to prepare a Q4T flight with 30 minutes' notice prevents chair flying and increases the number of Q4T flights needed to reach proficiency (n=1)	0	
Growing pains	2	Access to all information in the early stages was overwhelming and made it hard to know where to focus (n=1); SIM instructors forget that Avenger SNAs do not focus on one subject as much as traditional SNAs, and therefore have unrealistic expectations (n=1)	2	Confusion on proficiency advancing SNAs hurts their grades (n=1), rework or eliminate proficiency advancing (n=1),	0	
Other recommendations	1	Provide incoming Avenger SNAs with Avenger materials in advance to encourage getting ahead (n=1)	0		2	Combined instructor/student space for the traditional program to encourage interaction (n=1); increase flexibility of Mission Stage flights by decreasing emphasis on required items (n=1)
Other comments	0		0		1	Glad to have been in Avenger (n=1)

Table 39. Would you recommend Project Avenger?

	Pre-Flight Stage (17 respondents)		Qualification Stage (6 respondents)		*Mission Stage (14 respondents)*	
Response	%	Reasons	%	Reasons	%	Reasons
Yes	68.75%		100%		76.92%	
Yes, with reservations	18.75%	After growing pains (n=1), for most people (n=1), if schedule were less intense (n=1)	0%		7.69%	
No	0%		0%		0%	
No, with reservations	0%		0%		7.69%	
Unsure	12.5%		0%		7.69%	

Note. % = percent of the total number of responses to the question in each Stage. Sixteen SNAs responded in the Pre-Flight Stage, 6 SNAs responded in the Qualification Stage, and 13 responded in the Mission Stage.

10.5. Appendix 5: List of Abbreviations and Acronyms

ADS-B	Automatic Dependent Surveillance - Broadcast
ANCOVA	Analysis of Covariance
AoA	Angle of Attack
ATC	Air Traffic Control
ATN	Aviation Training Next
B&R	Breakup and Rendezvous
CAI	Computer Assisted Instruction
CNAF	Commander, Naval Air Forces
CNATRA	Chief of Naval Air Training
COTS	Commercial Off-The-Shelf
CTS	Course Training Standards
Det	Detachment
EP	Emergency Procedure
ERS	Event Raw Score
FITU	Flight Instructor Training Unit
FMS	Flight Management System
FTI	Flight Training Instruction
GK	General Knowledge
HOTAS	Hands On Throttle and Stick
HRPP	Human Research Protection Program
ICD	Informed Consent Document
IFR	Instrument Flight Rules
IFT	Instrument Flight Trainer

INAV	Instrument Navigation
IP	Instructor Pilot
IRB	Institutional Review Board
ITD	Immersive Training Device; also referred to as "VR Trainer" in the Student Feedback Questionnaire
LMS	Learning Management System
MCG	Master Curriculum Guide
MR	Mixed Reality
MXR	Multidisciplinary Extended Reality
NAS	Naval Air Station
NSS	Naval Standard Score
NATN	Naval Aviation Training Next
NAWCTSD	Naval Air Warfare Center Training Systems Division
OFT	Operational Flight Trainer
PMA-205	Program Management Activity-205; Naval Aviation Training Systems and Ranges Program Office
PQS	Personnel Qualification Standard
PTN	Pilot Training Next
RNAV	Area Navigation
SAIC	Science Applications International Corporation
SIM	Simulator
SNA	Student Naval Aviator
SSR	Special Syllabus Requirement
STUCON	Student Control

TIMS	Training Integration Management System
UTD	Unit Training Device
VFR	Visual Flight Rules
VNAV	Vertical Navigation
VR	Virtual Reality
XR	Extended Reality

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